Power and The Engineer

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AT a banquet given last June by the graduating mechanical engineers of the University of Illinois, Professors Thorpe and Goodenough of that institution spoke a few parting words on the successful engineer, using as their text the time-honored formula for indicated horsepower, which is known to almost every engineer.

$$\frac{PLAN}{33{,}000} = I.H.P.$$

One of our contributors was so impressed with their treatment of the subject that he forwarded the substance of what was said to POWER, and in slightly modified form we are repeating the gist of their remarks.

Although the talk was delivered to technical men, it applies equally well to the practical worker, and in fact to all men of any profession or trade.

To begin with, the "33,000" in the usual horsepower formula is a constant and therefore may be represented by a symbol.

For our purpose $1 \div 33{,}000$ is best represented by K, making the formula read:

$$PLANK = I.H.P.$$

As *P* comes first it is likely to be of great importance, which is true of *Patience*. No characteristic is more helpful under trying circumstances, and nowhere is the exercise of patience more necessary than in the engine and boiler rooms. The long hours of service, the Sunday jobs and the repair work common to even the best of plants, demand that this one quality be developed to an unusual degree.

L fittingly comes next; it ought to be prominent, for *Loyalty* to one's employer as well as to one's higher self is the essence of success. The good of the firm demands that all pull together. No minor jealousies or personal affairs should ever be given precedence, for, even from a selfish motive, loyalty to the firm means success to the individual.

Yet no engineer is a real success unless he has the next quality, *Accuracy*, denoted by *A*. There are few occupations in which accuracy is necessary to such an extent as that of the engineer.

As a fitting addition to the list of good qualities we have *N* for *Nobility*. Be noble! Treat your fellowmen as a man among men. Live as you would like to see men live—as you would have your son live.

Last, but by no means least, there is *K* for the indispensable *Knowledge* that enables the engineer to make the best use of the four qualities mentioned.

PLANK = I.H.P.

P = Patience **A** = Accuracy
L = Loyalty **N** = Nobility
K = Knowledge

I.H.P. = Important High Position

Turning to the other side of the equation, there are the symbols, *I.H.P.*, the equivalent of the first member. The result of such a combination of qualities can only be *Important High Position.*

You have then Patience, amplified by Loyalty, strengthened by Accuracy and magnified by Nobility; all these multiplying your Knowledge, and the whole resulting in Important High Position, or Success.

Adopt this "plank" and see how near the top it will land you.

Think it over.

Plant of the Holton Power Company

By Howard H. Bliss

A small hydroelectric plant at Holtville, Cal., supplying power and light to the various towns of the Imperial valley. The supply water is taken from the Colorado river at a point 60 miles distant from the power house and discharges below sea level.

The hydroelectric plant of the Holton Power Company, situated in the Imperial valley, that part of California latest to be developed, embodies some interesting features. This station, which is located at the town of Holtville, draws its water supply from a canal probably longer than that of any other power system in America; the water travels more than 60 miles from the diversion works to the point at which it is used, passing through parts of California and Mexico and twice crossing the international boundary. After giving up its energy at the station, the water is discharged below sea level and flows 40 miles to the Salton sea, a large lake whose surface is 250 feet below the level of the ocean.

The Holton company's hydroelectric plant and its steam auxiliary are the only generating stations in Imperial county, which is 4000 square miles in area. Although of moderate size, this plant normally supplies all the electric energy used by the 20,000 inhabitants of this district, and even sends some power across the border into Mexico.

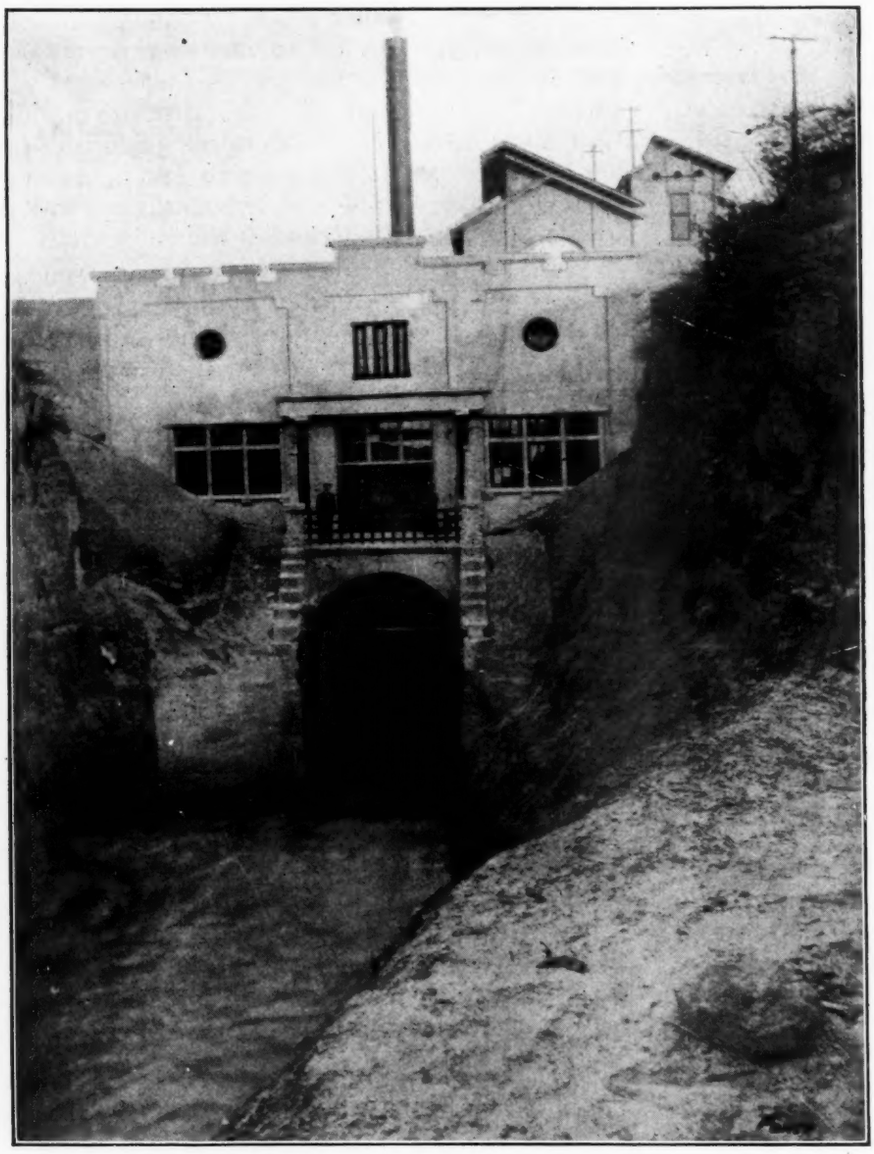


FIG. 1. NEW POWER HOUSE WITH OLD PLANT IN BACKGROUND

WATER SUPPLY

Water is taken from the Colorado river 10 miles below Yuma. It is carried south about a mile to the Mexican border and then 50 miles south and west through northern Mexico in the main canal of the California Development Company. From this great waterway, which is about 100 feet wide and from 6 to 25 feet deep, a branch turns north about 10 miles east of Calexico, and after crossing the international boundary, carries the water to Holtville. That portion of the water which is not diverted into the Holtville main is used for irrigating the land of the Imperial valley. A map of this district is shown in Fig. 2.

From a point on the Holtville main, 7 miles north of the boundary, the power company's 25x4-foot ditch extends 2½ miles westward and empties into a small reservoir. From this point the water is carried through a 54-inch pipe line to the power house. Practically the entire 1300 feet of this penstock is redwood stave pipe, buried underground. At a point close to the station where the static-pressure head is 33 feet, a riveted steel pipe replaces the wooden pipe. By means of a sharp bend this passes through the roof of the power house and terminates at the turbine, where the static head is 55 feet.

The draft tube is built up of steel plates, varying from a circular cross-section of 4 feet in diameter at the turbine to a 4x8-foot ellipse at a point 26 feet below. This pipe leaves the turbine vertically, but by means of two 45-degree bends, the course of the water is altered so as to issue horizontally. Although there is a drop of 26 feet between the shaft of the turbine and the center of the discharge outlet, the latter is submerged to such an extent that the suction head averages only about 20 feet.

From the waste weir beneath the power house the water is led through a short race to the bed of the Alamo river, thence to the Salton sea. Here it is evaporated, as the sea has no outlet. The hot sun and dry air of the valley are causing the gradual disappearance of this great body of water, having an area of over 200 square miles, despite the fact that it is continually supplied with large volumes of water from the waste weirs of the California Development Company.

BUILDING AND EQUIPMENT

The small building shown in Fig. 1 spanning the walls of a water-worn cañyon, houses the equipment. The structure is of concrete and has one main room, 52x29 feet, and several smaller rooms. The machinery was manufactured and installed by the Allis-Chalmers Company, and consists of a turbine, a three-phase

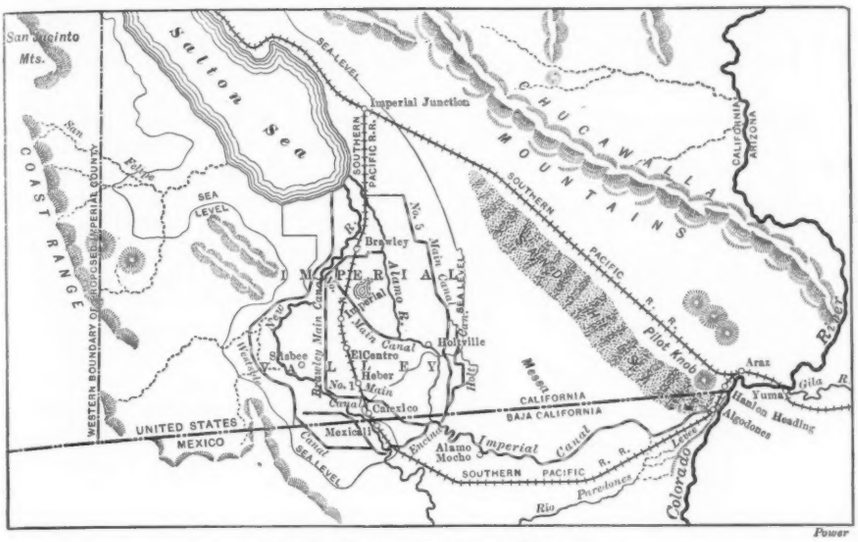


FIG. 2. MAP OF IMPERIAL VALLEY

generator and a step-up transformer set, with the usual switchboard and exciter equipment. The turbine is of the axial outward-flow type, double ended, with a horizontal spindle and runs at 450 revolutions per minute. Direct-connected to the turbine is a 2400-volt, revolving-field type of generator, rated at 700 kilowatts. The three transformers are connected in delta and raise the voltage to 15,000 volts at which the current is transmitted over the valley, the greatest distance being 24 miles, and is stepped down at the various points of utilization. A 15-kilowatt compound-wound exciter is belted to the main shaft. The generating set and switchboard are shown in Fig. 3, the latter consisting of four panels mounted on a concrete frame.

SURGE PIPE

To replace an old surge pipe, the action of which had been unsatisfactory, the company has just constructed a sheet-steel reservoir supported by a timber structure at the rear of the power house. The reservoir holds about 40,000 gallons when the plant is not running; when water is flowing through the pipe line and the head at the power house is reduced by friction, the water level in the reservoir is much lower.

DISTRIBUTION OF POWER

Power is transmitted by a pole line to the various towns in the district most of which use the power for both lighting and manufacturing purposes. The wooden poles were treated with hot carbolineum from the butt to 2 feet above the ground, but owing to the dry air of this locality they have shown no signs of decay.

Owing to the large number of manufacturing enterprises using power, the day load on the station is nearly equal to the night load. This results in an unusually high load factor.

The company has offered large inducements for consumers to use all they can for day motor loads, giving a rebate of 75 per cent. from the regular rate of 20 cents per kilowatt-hour.

In order to cope with emergencies, the old plant, shown in the background of Fig. 1, is kept in readiness to supplement the new plant. It contains a 250-kilowatt turbo-generator set working under an available head of 52 feet.

AUXILIARY STEAM PLANT

At El Centro is located the steam auxiliary plant containing a St. Louis tandem-compound Corliss engine, belt-connected to a 250-kilowatt generator of the revolving-armature type. To supply steam to the engine there are two Stirling boilers, rated at 300 boiler horsepower each, using oil as fuel. The plant is run non-condensing, with no superheater between the high- and low-pressure cylinders, hence it is very extravagant in the use of fuel.

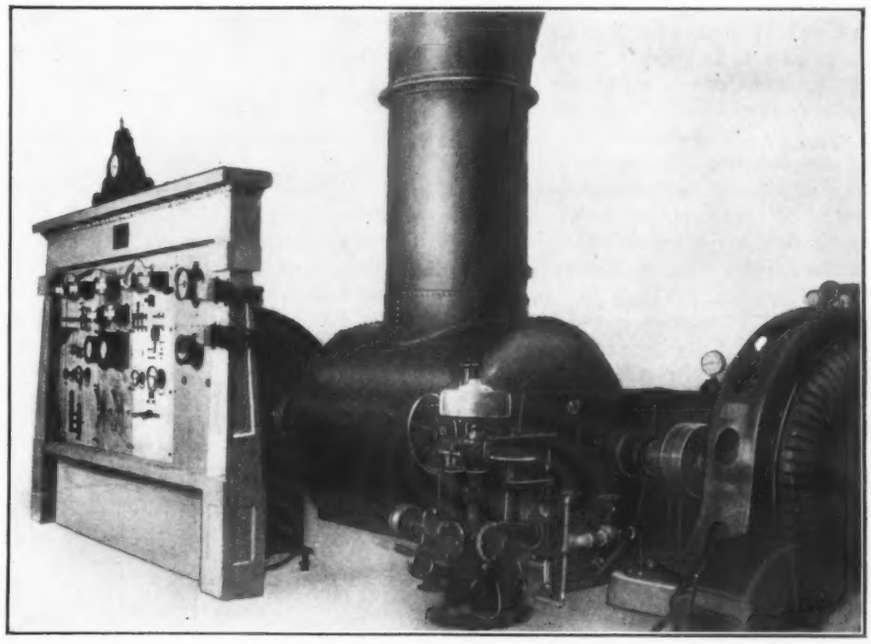


FIG. 3. GENERATING SET AND SWITCHBOARD

Not long ago, S. Kirlin met Eccentric Si, who is a queer fellow at best. He jotted down a few of his most brilliant remarks, and here they are.

I writ t' th' POWER fellers an' ast 'em ef they cud tell us whar we cud sell th' old worn-out rope frum our transmishun system. They writ back an' told us t' try a cigar factery.

Old Hal Mossback bot a farm. Says he's goin' t' raise hydraulic rams on it. Sed th' big rain tother day washed everthin' off'n it 'cept th' morgige.

They'r bildin' a nursin' bottle factery over t' Jayville. When th' ingin kum fer it th' feller thet's goin' t' play ingineer sent th' eccentric back t' th' factery an' roasted 'em fer sendin' out a wheel with th' hole bored so fer frum th' center.

Sum wun told Bill Grimes thet ef he'd put a bushel uv green cucumbers inter his biler thet it'd take th' scale out'n 'er. Bill opened 'er up t' put 'em in an' ther wuz so dumd much scale in 'er thet he didn't hev room fer only a peck. When he fired up an' started th' ingin she turned over a few times, went t' groanin' an' doubled up her connectin' rod.

Bill Blowoff's biler blowed up with him on top uv it. He went up in th' air 'bout a quarter uv a mile an' kum down in th' crick; didn't hurt him much, but he got sorter damp 'fore they got 'im pried loose frum th' mud. Sid Diggles told Bill thet he wuz a dumd fool fer kumin down after gettin' so clost t' heaven, fer he wasn't likely t' ever get thet nigh t' it agin.

Combination Engine and Boiler

By Warren H. Miller

In this product of German design and manufacture the engine, boiler and auxiliaries are combined, permitting a high degree of superheat to be utilized by the engine and doing away with the numerous heat losses found in the average plant. The water consumption of this type of engine is about 10 pounds per horsepower-hour.

It is a big step in economy from the 35 pounds steam consumption of the average 60-horsepower high-speed engine to the 10 pounds steam consumption of the German combination steam engine and boiler of 60 horsepower, and a still greater advance from the five pounds of coal per horsepower-hour of small 60-horsepower plants to the one pound per horsepower-hour of the combination engine and boiler. This disparity may be accounted for by the reduced cylinder condensation, and by careful elimination of the apparently insignificant losses which ordinarily occur about a small plant. The Germans have developed possibilities in a careful use of coal, fire and water, so as to obtain in the ordinary small semi-portable plant a better economy than is realized in our large central stations.

The illustrations show two types of these engines: one, a noncondensing simple engine with the boiler and feed-water heater attached; the other, a compound engine with the boiler, feed-water heater and a jet condener attached. The sectional view gives a clear idea of how the engine, boiler and auxiliaries are combined, making the unit semi-portable; for all that it requires is two brick piers, to install it ready for use. The boiler is of a type quite different from that ordinarily seen. The cylinder and the steam dome are cast in one piece and are riveted direct to the shell of the boiler, and at least half the boiler is superheating surface.

It can be readily seen that whatever mechanical difficulties these arrangements may introduce, they at once eliminate condensation and radiation from the steam pipes and cylinder walls; return all unused heat to the boiler instead of to the air; and utilize the heat from the waste gases for superheating the steam. Yet there is nothing in this disposition of the parts that constitutes poor mechanical design.

For the purpose of contrast, compare this type of engine with an ordinary isolated boiler and engine plant of from 60 to 100 horsepower. Usually a plant of this size has an internally fired locomotive-type boiler, with a 25-foot iron stack. The portion below the grate is exposed to direct radiation to the ground, and the stack temperature is anywhere from 500 to 600 degrees. Sometimes the boiler is lagged, sometimes it is not; the feed water is drawn from a barrel or possibly from a primitive hotwell; and the steam pressure is usually about 80 pounds. On the other hand, the combination engine and boiler herein described has a corrugated-iron, internally fired furnace which can easily be kept clean and efficient; and the gases, after passing through the tubes, pass over the high-pressure superheating coils located in the smoke box, returning over a second set of low-pressure superheating coils, and thence to the stack at about 370 degrees. The whole unit is lagged and a feed-water heater which raises the feed-water temperature to 170 degrees is located in the path of the waste gases. The usual steam pressure is about 180 pounds.

In the typical small steam plant there is usually about 25 feet of piping between the boiler and the engine; the cylinder of the engine is lagged with cast-iron plates fitted over an asbestos filling; a complete and elaborate system of drains is provided; the engine is simple noncondensing and runs at about 250 revolutions per minute. With the combination plant there is no steam piping exposed to the temperature of the air; the steam dome and the low-pressure cylinder are cast in one piece with the steam in the dome surrounding the cylinder; the high-pressure cylinder is direct-connected to the high-pressure superheater; the steam enters the high-pressure cylinder at about 650 degrees Fahrenheit and expands down to about 235 degrees; it is then reheated to 360 degrees, and is again expanded to a vacuum of 27 inches at which it enters a jet condenser located at the side of the boiler. The revolutions of the engine are 170. Practically all the refinements found on the largest engines are present in this little plant, such as superheating the steam between the high- and low-pressure cylinders and jacketing both of these cylinders with an envelop of steam or gases hotter than the interior of the cylinder.

Such radical improvements in steam economy when introduced into the engineering world are usually either adopted at once by steam users, or are rejected because of some inherent de-

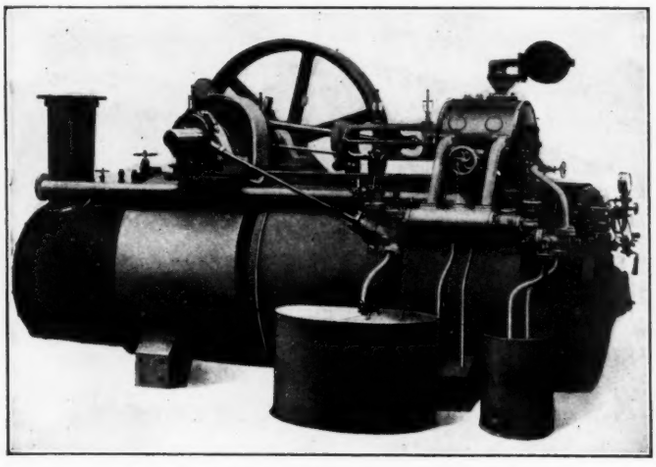


FIG. 1. SIMPLE NONCONDENSING ENGINE

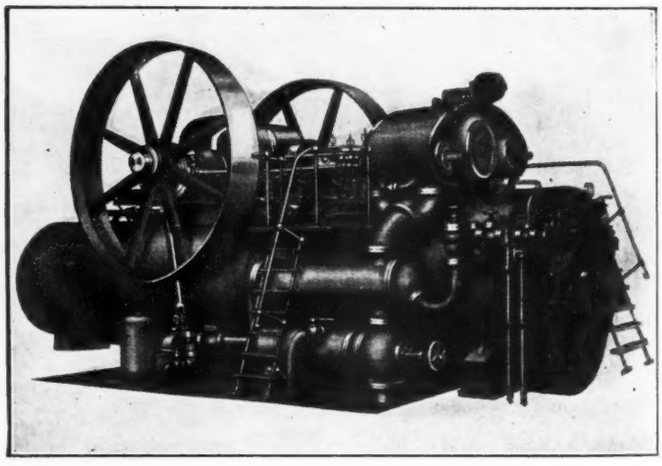


FIG. 2. COMPOUND CONDENSING ENGINE

fect in operation. During the first five years that these engines were placed on the market, approximately 1500 simple engines, aggregating 140,000 horsepower, and 800 larger compound engines of from 400 to 500 horsepower, aggregating about 1,500,000 horsepower, were introduced into England and the Continent by one firm of builders alone. Their field of application is broad, and includes isolated electric-light plants, agricultural machines, shops, mill work and many portable installations. They are provided with furnaces for burning either anthracite or soft coal, or special furnaces for burning tan bark, logs, straw, corn husks, lignites, coffee husks and other combustible refuse. They are also arranged for crude oil and other liquid fuels.

RESULTS OF TESTS ON STEAM ENGINE.

	Test No. 1.	Test No. 2.
Mean speed of engine in revolutions per minute	219.3	219.2
Mean speed of countershaft in revolutions per minute	230.7	230.4
Total indicated horsepower	47	59.4
Brake horsepower of engine (3 per cent. added for loss by belt and countershaft bearings)	43.2	55.1
Mechanical efficiency, per cent	91.9	92.7
Consumption of steam per indicated horsepower per hour, pounds	10.02	9.5
Consumption of steam per brake horsepower per hour, pounds	10.9	10.29
Heat units required per indicated horsepower per hour, feed water at 100 degrees Fahrenheit, B.t.u.	6063	5903
Coal consumption per indicated horsepower per hour, pounds	1.23	1.16
Coal consumption per brake horsepower per hour, pounds	1.32	1.23
Thermal efficiency of the engine (measured from feed water at 100 degrees Fahrenheit), per cent	19.3	19.8
Total efficiency of plant per brake horsepower, per cent	13.4	14.3
Barometer, inches	29.96	30.05
Mean vacuum (by barometric reading), inches	26.1	26.3
Oil consumption per brake horsepower per hour for cylinder, ounce		0.06
Oil consumption per brake horsepower per hour for gearing, ounce		0.08

RESULTS OF TESTS ON THE BOILER.

	Test No. 1.	Test No. 2.
Duration of test, hours	5	4
Mean steam pressure, pounds per square inch	180	180
Temperature of saturated steam degrees Fahrenheit	373	373
Temperature of steam at admission to high-pressure cylinder degrees Fahrenheit	644	680
Temperature of steam at admission to low-pressure cylinder degrees Fahrenheit	340	376
Mean superheating in first superheater....degrees Fahrenheit	304	342
Mean superheating in second superheater, degrees Fahrenheit	136	160
Pounds of feed water evaporated per square foot of heating surface per hour	3.05	3.68
Mean temperature of feed water, degrees Fahrenheit	100	100
Total evaporation.....pounds	18.02	18.16
Mean draft in smoke box, water column in inches	0.27	0.27
Mean temperature of the engine room.....degrees Fahrenheit	70	73
Mean temperature of hot gases in the furnace, degrees Fahrenheit	1227	1347
Mean temperature of hot gases in front of the first superheater....degrees Fahrenheit	698	787
Mean temperature of hot gases in front of the second superheater....degrees Fahrenheit	494	526
Mean temperature of hot gases in smoke box, degrees Fahrenheit	376	412
Efficiency of boilers, including superheaters.....per cent.	75.4	77.7

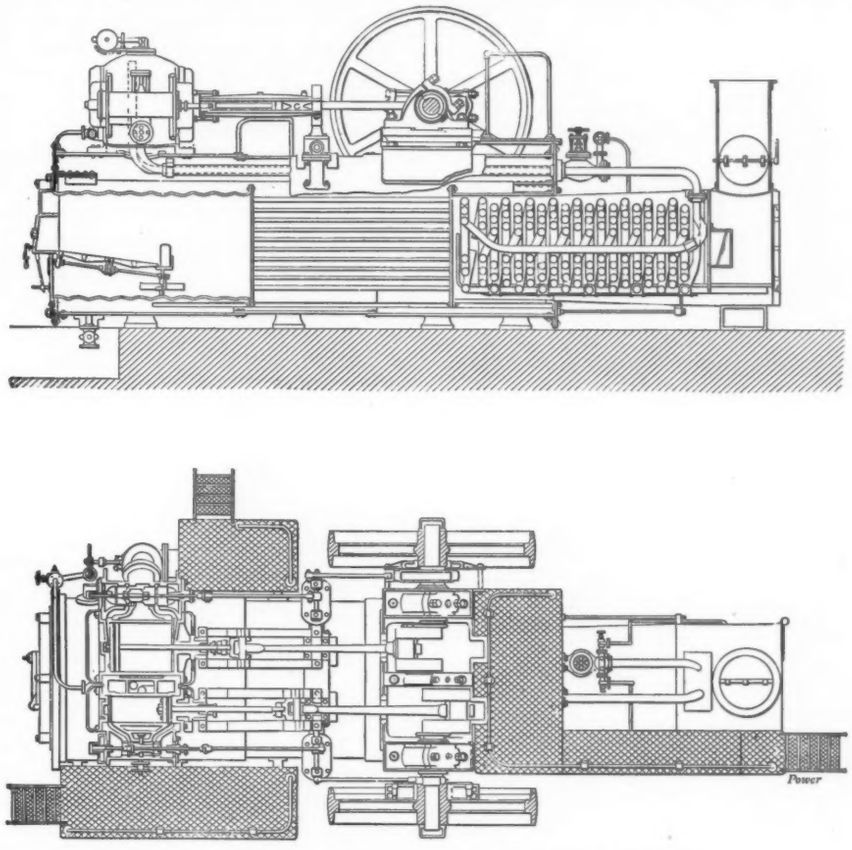


FIG. 2. PLAN AND ELEVATION OF COMPOUND ENGINE

There is no particular difficulty introduced by having the cylinders located in the stack or in the steam dome. In both, the end plates are entirely exposed, and as the exterior of the cylinder walls seldom requires attention, their inaccessibility counts but little. The clearances are arranged to allow for the additional expansion of the steam due to superheat. At the temperature used the steam has about 24 per cent. greater volume per unit of weight than when saturated; this gives a correspondingly greater horsepower per pound of steam. The piping of the superheaters is mild steel, as are all the leads to the cylinders. The cylinders are cast of tough gray iron and are tested by hydraulic pressure after being riveted and calked. The stuffing boxes of the piston rods and valve rods have a high grade of asbestos packing and give no particular trouble in operation. The pistons are especially constructed for use with superheated steam, the moving parts being light and having well balanced areas. The steam valves are of the balanced piston type, with steel rings and cast-iron bodies. The rest of the engine is very similar in design to ordinary steam engines of similar size and running at 200 revolutions per minute, although no attempt has been made to introduce a crank-oiling or gravity-lubrication system; they are lubricated by oil cups located at various points.

The boiler is designed so that by unbolting and removing the rear head, the entire interior, including the furnace, tubes and superheater, may be removed in one piece for the purpose of cleaning.

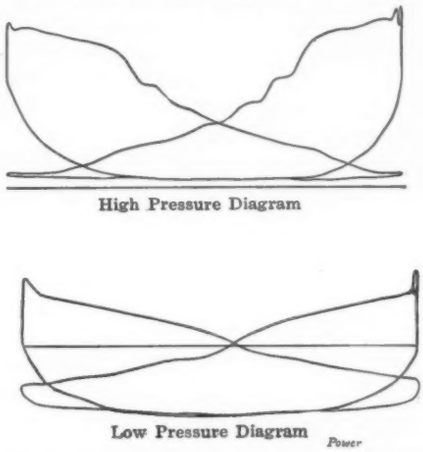


FIG. 4. DIAGRAMS TAKEN FROM COMPOUND ENGINE

The front head is smaller than the rear head and is bolted to the inside of the flange; this is a simple expedient, and one that should give no trouble if proper gaskets are used; at the same time it vastly simplifies the work of cleaning.

For removing the soot from the tubes of the superheater, handholes are provided in the smoke box; this permits them to be blown down daily without going to the trouble and expense of a thorough cleaning, which can be given when the whole interior of the boiler is removed.

These engines and boilers are made in about fifty different sizes which are divided into three general groups: first, the small, simple engine of from 12 to 115 horsepower, having the cylinder located in the steam dome and provided with one superheater; second, the cross-compound engine of from 45 to 430 horsepower, having both high- and low-pressure cylinders placed side by side in the steam dome, provided with one superheater and running either condensing or noncondensing; third, the tandem-compound engine of from 20 to 85 horsepower with the high-pressure cylinder located in the steam dome and the low-pressure cylinder in the smokestack, having superheaters for both the high- and low-pressure steam.

Fig. 4 shows diagrams taken from one of these compound engines. There is a sudden drop in the pressure immediately after admission, due to the drop in the temperature of the steam, the cylinder not yet having been heated sufficiently after the previous expansion; also there is considerable reëvaporation during expansion, due to the cylinder being jacketed with live steam and the return of the heat which was taken up by the cylinder walls at admission.

The results of a test on a 40-horsepower engine of this type by Professor Jesse, of the Royal Technical Institute of Berlin are shown on the preceding page.

Serious Troubles from Small Things

By T. A. Emerson

Troubles with prime movers in central stations, sometimes involving a total or partial shutdown, are frequently caused by negligence on the part of attendants or by some apparently insignificant detail which has been overlooked in the original layout. A few such incidents are cited.

One of the most common causes of trouble in a power house is the failure of the lubrication system in some form or another. This is somewhat surprising considering the attention that has been given to the subject for so many years, but apparently no system, whether forced or gravity feed, has been adequate to overcome the human element of carelessness. One of the most essential duties of the watch engineer is to go around at frequent intervals and see that the oilers are doing their duty. An instance of this may be cited where serious trouble was occasioned by an inexperienced oiler. The bearings of the engine, driving the air pump of one of the main units, were lubricated by means of siphons, and the oiler, being inexperienced in this class of work, instead of pushing the wicks down into the tube in the oil cup, simply dropped them into the oil well, with the result that the engine was started and run for a short time with its bearings quite dry. Of course, it could not withstand this long, and the engineer in charge soon found that this main unit was running against atmospheric pressure and could not carry the load. Consequently, until the peak of the load was over, the station was in a demoralized state and low-voltage complaints were received from all parts of the lines.

Another instance of failure in lubrication occurred with the sight-feed lubricator on a high-speed engine. The piston of the lubricator had become clogged and no oil was passing into the engine. It was impossible to open the lubricator while the engine was running, and it was also necessary to keep the engine running until the heavy load had passed. Fortunately, emergency cups had been fitted at the tops of the cylinders on each line, and the cylinders were kept lubricated by flushing them at frequent intervals; and the rods were kept from heating by applying oil swabs.

An instance somewhat similar to the first one related was due to the breaking of the governor belt and the consequent racing of an engine which drove a compound circulating and air-pump set. This governor was of the ordinary ball type and when the balls were raised the steam was cut off. Hence, when the belt snapped, full steam was admitted to the engine, causing it to race. It was necessary to shut the stop valve of the air-pump engine as quickly as possible in order to avoid any damage, and the main engine, whose vacuum was thus affected, began to exhaust against the atmosphere by means of the automatic atmospheric valve. This lowered the voltage, and in order to bring the lamps up to their normal brilliancy, it was necessary to start the air-pump engine again and govern it direct from the stop valve, that is, adjust it according to the duty on the pumps; in this way the run was completed, although it meant taking a man from other duties and keeping him at watching the pump. This incident emphasizes the necessity of a periodic overhauling of all details; if the belt had been regularly overhauled it is probable that such trouble would have been avoided.

Intimately connected with lubrication is the subject of the packing used in the stuffing boxes of the engine. No inexperienced hand should be allowed to attend to this part of the maintenance. A breakdown, which fortunately did not affect the running of the station, owing to a spare unit being available, was due directly to a badly packed stuffing box. This box, which was on the high-pressure cylinder, was packed with metallic packing but the work had been done very hurriedly. The first indication of trouble was the excessive dryness of the rod when the engine was running. Immediately after this was noticed, and before anything could be done, the friction of the rod caused the packing to run. The load was at once taken off, and the engine was shut down. Upon examination the rod was found to be only slightly scored, so that without any further trouble the gland was repacked. Care was taken to screw down the gland little by little on each stud and to keep the gland true with the rod.

In the early days of electric lighting, the governors of the engines were often made too light to take up the fluctuations in the load, but this trouble is now seldom met with. The specifications for electric-light-plant equipment are now so severe as regards governing, that with careful maintenance there should be very little trouble due to hunting or surging. However, a rather curious instance of governor trouble occurred with a certain marine type of engine which operates its governor from the crank shaft through a flexible coupling. A set of screws on this coupling slacked back, and the sleeve of the governor could not make the full travel. As the engine was governed on the throttle this could not be closed sufficiently to control the speed of the engine at light loads; therefore, it became a very difficult matter to parallel the alternator, coupled to the engine, with the other machines. It was some time before the cause was discovered and at first it puzzled the engineer in charge.

The subject of piping being so intimately connected with prime movers, reference may be made to the very common practice of leading all the exhaust branches from the engines into one common exhaust pipe. The reason for this system being adopted is that the arrangement permits of cheapness, but the method has its dangers. In one particular instance the exhaust steam from several engines was led into one large exhaust pipe; the pipe cracked and occasioned such an escape of steam as to compel the shutting down of the whole plant until the crack was temporarily repaired.

Care and Operation of Steam Boilers

By William Westerfield

A discussion of the proper and improper methods of firing and their influence upon combustion, together with some useful hints upon cleaning fires.

Efforts to secure economy and efficiency in operation should begin in the boiler room, not that these factors are more important there than elsewhere, but it is not wise to seek them in one part of the plant and neglect them in another. As generation of power begins in the boiler room, it is the logical place to begin to locate losses and errors that count against efficiency and economy. Then, in order, the entire equipment should be gone over, studying every part in its relation to the whole and learning what each unit is expected to do, and if it is not giving the proper service the cause should be found and removed.

One of the first things to do upon taking charge of a boiler room is to see that the boilers are properly fired and that they are supplied with water at as nearly a uniform rate as possible. Every engineer ought to know how to properly fire a boiler, because if he does not he is liable to be victimized in the boiler room by those who are either too lazy or too ignorant to do the work properly.

It is important that the fireman understand the part which air plays in the process of combustion. The carbon and hydrogen which forms the greater part of coal, will not burn unless combined with the oxygen of the air, and the amount of heat produced from the combustion will depend upon the proportions of air and fuel gases, also upon the nature of the compound formed by the mixture, which is dependent upon the temperature of the furnace. To make this clear, carbon is the principal element in the fuel, and oxygen the element in the air, upon which combustion is dependent. One pound of carbon uniting with two pounds of oxygen results in perfect combustion, the product being carbonic-acid gas, or CO_2, developing 14,500 heat units. The term CO_2 expresses the quantity of each element in the compound; that is, one part of carbon is expressed by C, and two parts of oxygen by O_2. If insufficient oxygen or air is supplied to the furnace the carbon or combustible matter will not burn to the carbon dioxide usually formed, and the resulting product will be CO, or carbon monoxide, the term CO indicating equal quantities of the two elements. In this case only 4450 heat units will be developed, which is a loss of 69 per cent. of the heat value of the fuel as a result of insufficient air.

A large volume of air is needed with a quick-burning fuel, like bituminous coal, at the moment of ignition when a fresh charge has been placed on the fire. The free gases in this class of fuel are distilled very rapidly, in fact so rapidly that it is impossible to supply air in sufficient quantity to secure perfect combustion, as is evidenced by the volume of smoke emitted from the stack at this time. After the free gases have been distilled and while the solid carbon of the fuel is being burned, but a comparatively small quantity of air is required.

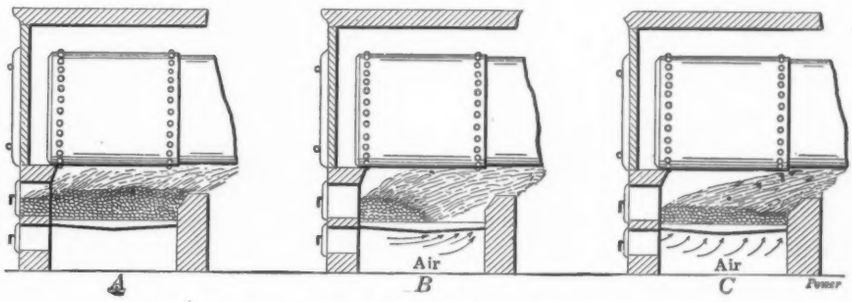
A good index to furnace conditions is the appearance of the incandescent bed of fuel. If the fire burns down brightly, so that after the distillation of the volatile gases it appears as a white incandescent mass, one may be assured that conditions are nearly right. But, if the fire burns to a dull red, it is certain that the fuel is not being burned to advantage. For this last condition there may be many causes: The draft may be insufficient or the boiler setting may have cracks in it through which cold air enters, thus chilling the gases before they have come in contact with the heating surfaces. The boiler settings should be as nearly air tight as possible, so that the air will have to pass through the grates and the fire. It may also happen that the draft through the grates is insufficient on account of heavy firing, and good combustion is impossible where fires are carried so thick as to seriously obstruct the draft.

One method of firing often met with is shown at *A* in the accompanying illustration. The fuel is piled on the grates so long as there is space for it between them and the boiler shell. As very little air can get through such a fire, it is clear that poor combustion will result. At *B* is shown another method too often met with. In this case the fireman wants coal where it can be seen, and yet not be consumed fast enough to require frequent replenishing. In this case what little heat that is produced by the combustion of the fuel is taken up by the great volume of cold air passing up through the bare grates between the fuel bed and the bridgewall. A good fireman will maintain the fire in a thin even bed, as shown at *C*, keeping the grates free from ashes and clinker, so that air may pass freely through the grates and fuel bed. Since there is a difference of about 69 per cent. in favor of the last mentioned method over the others, it would seem that the fireman does not always receive the consideration due him.

When fresh fuel is added to a fire it is best to place the first shovelfuls well up toward the bridgewall, and fire from this point toward the furnace doors. Thus, the fire is not obscured by the dense smoke from the fresh fuel, and the fireman can see just where the fuel is placed.

When cleaning the fire of a boiler be sure to have the other boilers on the same load doing their best. Never allow all fires to become dirty at the same time. When ready to clean the fire under one boiler cut down on the feed water so that the boilers under which the fires are not being cleaned will be able to carry, without unnecessary forcing, the additional load thus temporarily thrown upon them. It is much better to arrange the intervals of cleaning for the different boilers so that there will be plenty of time for building up the new fire, to avoid great changes in pressure and temperature. It often happens that poor judgment in this matter is responsible for a heavy drop of pressure, and that a number of boilers will have their fires cleaned one after the other. In this case as soon as the fires are cleaned it is necessary to begin forcing them, and in a short time they have been ruined and are ready for another cleaning.

There are so many fuels requiring different handling that it is almost useless to give instructions of a general nature as to how to clean fires. The essential point to be kept in mind is to do it in a manner that will cause the least varia-



CORRECT AND INCORRECT WAYS TO MAINTAIN A FIRE

tion of temperature in the boiler. A very good plan with bituminous coals is to build a bank on one side of the grate and add to this, a little at a time, until there is a bank of coked fuel. In the meantime the other side is allowed to burn down as low as conditions warrant. Then with the slice bar all clinker should be loosened from the grates and pulled out with the hoe. The bank of coked fuel may now be shoved over to the clean side of the grates and the work with the slice bar and hoe repeated on the other side and fuel scattered from this side over the clean grates with such additional fuel as judgment warrants.

Time is a very important factor in cleaning fires, and preparation should be made for the task. Every tool that will be required should be placed within handy reach as every moment wasted during the cleaning process means keeping the boiler out of commission just so much longer.

Inequality of Piston Displacement

By Guy Wise

In the present analysis of the problem of unequal piston displacement due to the angularity of the connecting rod, the treatment is as simple as possible consistent with a clear understanding of the facts; the elementary case of the crank and slotted yoke serving as an introduction to the subject.

While the crank and connecting rod as used for changing reciprocating to rotative motion is a simple mechanism, its use introduces some peculiar problems worthy of study, one of which is the variation of piston displacement. This problem has probably been made familiar to most engineers in the statement that the piston travel is greater for the first quarter revolution of the crank travel than it is for the second quarter.

If the crosshead is driven directly by the crank then the conditions are represented by the crank and slotted yoke shown in Fig. 1. With this device the movement of the crosshead corresponding to any quarter turn of the crank is of the same amount. This may be proven and the displacement of the crosshead determined for a movement of the crank through any angle, as follows:

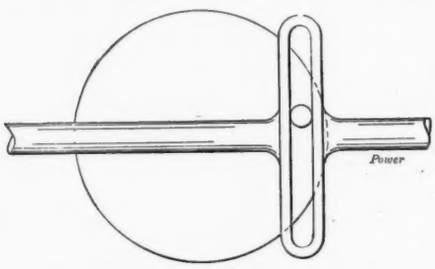


FIG. 1. YOKE AND SLIDING PIN

In Fig. 2 the crank BP of length X, has started from A and has moved through the angle ABP (for convenience call this angle B), while at the same time the slotted yoke has moved from A to N. It is evident that

$$AN = AB - BN. \qquad (1)$$

Also in the right triangle BNP,

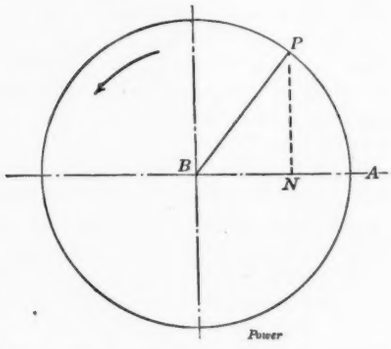


FIG. 2. RELATIVE TRAVEL OF CRANK PIN

$$Cosine^{*}\ B = \frac{BN}{BP}$$

From which, $BN = BP\ cosine\ B$.

Now, AB and BP are equal. Substituting these known values in equation 1, it becomes

$$AN = BP - BP\ cosine\ B = BP\ (1 - cosine\ B). \qquad (2)$$

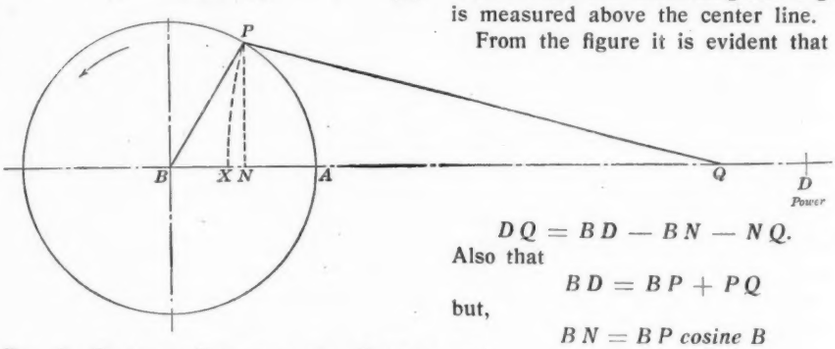


FIG. 3. DIAGRAM REPRESENTING CRANK AND CONNECTING ROD

By means of equation 2, it is possible to determine the displacement of the crosshead for any particular position of the crank. For example, the displacement when the crank has moved through an angle of 60 degrees is

$$AN = BP\ (1 - cosine\ 60\ degrees).$$

The value of the cosine of 60 degrees is found, in the table of natural cosines printed in all engineering handbooks, to be 0.5. Therefore

$$AN = BP\ (1 - 0.5) = 0.5\ BP.$$

When the crank is vertical or has moved through an angle of 90 degrees, then

$$AN = BP\ (1 - cosine\ 90\ degrees).$$

The cosine of 90 degrees is found to be zero, hence

$$AN = BP\ (1 - 0) = BP.$$

The results just determined for the crank and slotted yoke show that between 60 and 90 degrees the space traveled by the crosshead is the same as from 0 to 60 degrees, and that when the crank is at mid-position the crosshead is also at mid-position.

The above discussion gives some idea of the action in the case of the crank and slotted yoke and is preliminary to taking up the case of the crank and connecting rod shown diagrammatically in Fig. 3. In this sketch the crank BP has started from A and has moved through the angle ABP (denoted by B), the connecting rod PQ has moved through the angle NQP (denoted by Q), and has drawn the crosshead from D to Q. The displacement DQ of the crosshead is measured from D, the crank angle B is measured from A and the connecting-rod angle Q is measured above the center line.

From the figure it is evident that

$$DQ = BD - BN - NQ. \qquad (3)$$

Also that

$$BD = BP + PQ$$

but,

$$BN = BP\ cosine\ B$$

and

$$NQ = PQ\ cosine\ Q.$$

Substituting these values in equation 3 it becomes

$$DQ = BP + PQ - BP\ cosine\ B - PQ\ cosine\ Q.$$

Rearranging the terms gives,

$$DQ = BP\ (1 - cosine\ B) + PQ\ (1 - cosine\ Q). \qquad (4)$$

Equation 4 is the means of calculating the piston displacement for any crank angle. A comparison of equations 2 and 4 shows that the first term, BP (1 —

*In a right triangle the ratio of the leg adjacent to any angle to the hypotenuse (the side opposite the right angle) is the cosine of the angle in question.

cosine B), of equation 4, is the same as the displacement for the crank and slotted yoke given by equation 2; so that the last term of equation 4, PQ (1 — *cosine* Q), must represent the amount of the inequality of travel due to the use of the crank and connecting rod, the inequality varying in value as the angle Q varies. Graphically this inequality equals the distance XN. This is therefore what is meant by saying that the inequality between the head-end and crank-end displacements of the piston is due to the angularity of the connecting rod of a reciprocating engine.

Thermometer Correction Curves

By Frederick Ray

With an ordinary mercurial thermometer and thermometer well it is difficult to obtain accurate readings owing to the fact that a large portion of the thermometer stem projects out of the well and is exposed to the temperature of the air. The accompanying set of curves shows the corrections to be added for various immersions of the thermometer stem and various temperatures.

The ordinary mercurial thermometer is graduated when entirely submerged; hence, to obtain the correct temperature reading with such a thermometer it is necessary to submerge it until the whole of the mercury in the bulb and in the stem is surrounded by the fluid whose temperature is desired. In practice this is often impossible, especially when using thermometer wells in taking temperatures of fluids in pipes. These wells are usually only a few inches deep, whereas the thermometers are from 12 to 18 inches long; consequently a large proportion of the graduations are outside the well and exposed to the temperature of the surrounding air. This results in the exposed part of the stem, as well as the part of the mercury column contained within it, being at the temperature of the air instead of at the temperature of the well.

As the expansion of the glass due to the temeprature change is only about one-seventh that of the mercury, it follows that the volume of the glass capillary tube varies about one-seventh of that of the mercury column contained within the tube for any given change in temperature. Therefore, the length of the mercury column must increase or decrease as the temperature of the stem is increased or decreased. It is evident that if the indicated temperature of the stem is different from that which would result from complete immersion, a correction must be made to the readings to obtain the correct temperature at the bulb. Following is the method of calculating such corrections and the results for various immersions and temperatures are given in the accompanying set of curves.

The mean coefficient of expansion of mercury varies about ½ per cent. in the range covered by the set of curves which have been computed, using a coefficient of 0.000102 as an average value; this

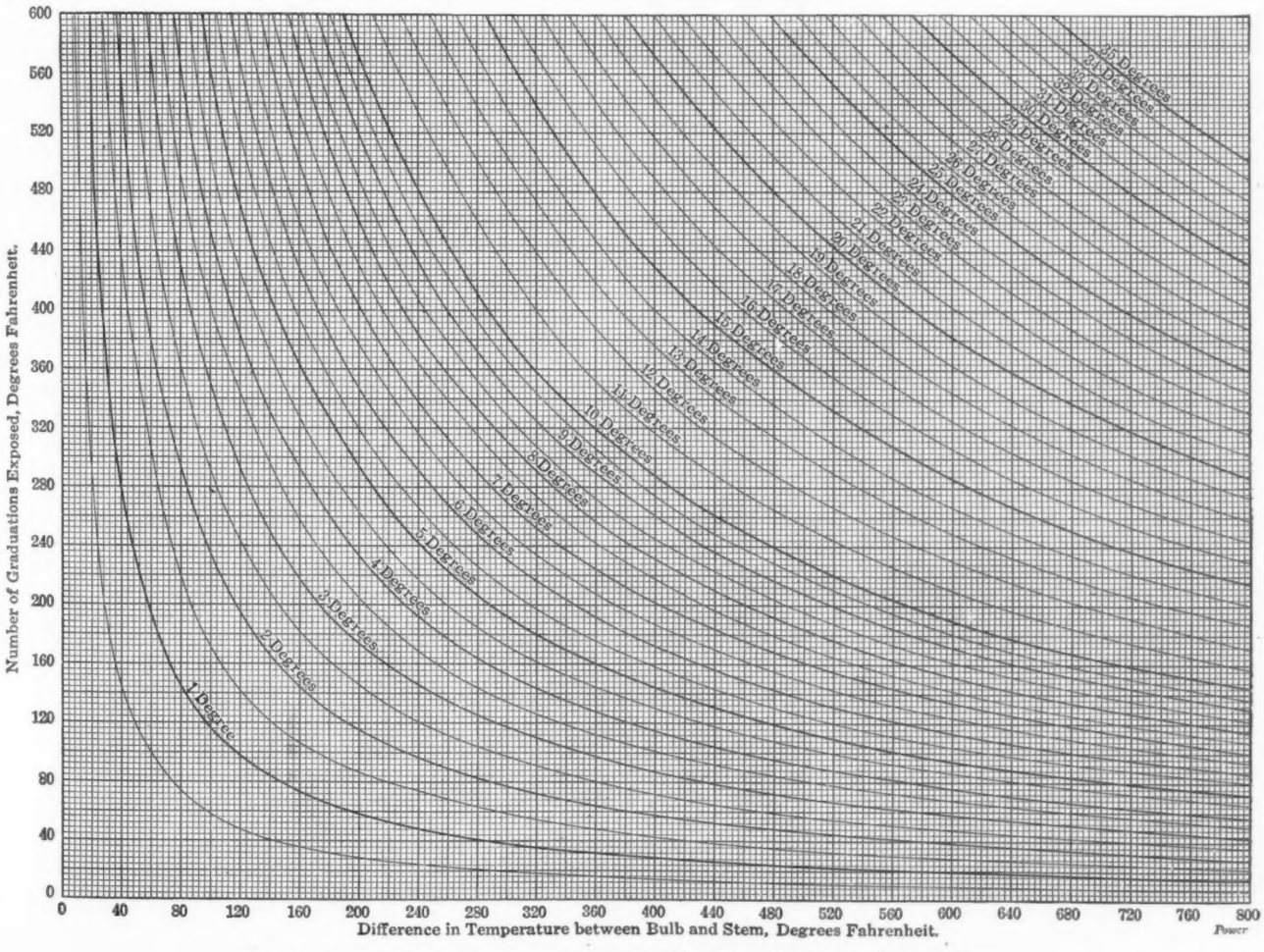


FIG. 1. CORRECTION CURVES FOR VARIOUS IMMERSIONS OF THE THERMOMETER

makes the maximum error not over ¼ of 1 per cent. Considering the mean cubical expansion of glass as 0.0000147, the reading on the Fahrenheit scale may be expressed by the formula:

$$\theta = 0.0000873\ X\ Y,$$

where

θ = Number of degrees correction to be made to the scale reading.

X = Number of graduations exposed to the air.

Y = Number of degrees difference between the indicated temperature of the bulb of the thermometer and that of the air or the stem of the thermometer.

If the stem is cooler than the bulb, as is most always the case, the correction is added; if hotter, it is subtracted. By assuming certain values for θ and solving the equation, the various points in the corresponding curves were obtained.

As an example in the use of the curves, refer to Fig. 2, which shows the cross-section of a steam pipe into which is screwed the ordinary mercury well containing a mercurial thermometer. The column of mercury in the stem of this thermometer stands at 370 degrees and the top of the well extends to the graduation corresponding to 180 degrees, leaving 190 degrees of the stem exposed to the air. A second thermometer suspended beside the first one shows that the temperature of the air surrounding

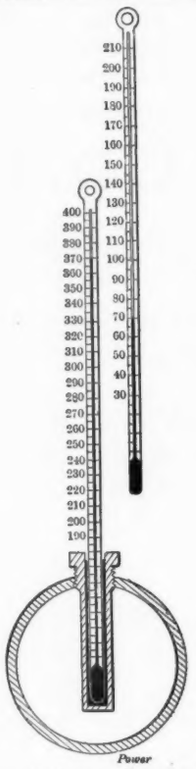


FIG. 2. THERMOMETER INSERTED IN STEAM PIPE

the stem is 70 degrees. Hence, the difference between the temperature of the well and that of the air is 300 degrees. Referring to the curves, the intersection of the horizontal line corresponding to 190 degrees exposed, with the vertical line corresponding to 300 degrees difference in temperature, is found to be on the curved line marked 5 degrees. This means that a correction of 5 degrees should be added to the thermometer reading, making the correct temperature 375 degrees Fahrenheit instead of 370 degrees.

The curves have been drawn for the Fahrenheit scale and will not apply directly to Centigrade readings. Such readings can be reduced to the Fahrenheit scale, the corrections obtained and then changed back again. The same result, however, can be obtained in a simpler manner by taking the Centigrade readings and finding a correction from the curve, then by multiplying this correction by 1.8 the result obtained will be the desired correction expressed in degrees Centigrade. In the example given, if the thermometer readings are assumed to be degrees Centigrade, and these readings are applied to the curve just as before, the 5 degrees correction must be multiplied by 9/5, which gives 9 degrees Centigrade as the actual correction.

Measuring and Expressing Vacuum

By R. M. Neilson

Instead of expressing the vacuum in inches of mercury and then referring to the barometer to compute the absolute pressure, it is common in Great Britain to correct the vacuum reading to apply to a 30-inch barometer and thus give the corrected reading only. The custom of expressing vacua as percentages is not to be recommended.

It is usual in steam-engine practice, as well as in other industrial connections, to express pressures below atmosphere as "inches of vacuum." By this is meant that the pressure in question is less than atmosphere by an amount equal to the pressure given by a column of mercury of a certain hight measured in inches. For example, by, say, 25 inches of vacuum is meant a pressure which is less than atmospheric pressure by an amount equal to the pressure given by a column of mercury 25 inches high.

In the accompanying illustration, V is a vessel, the pressure within which is less than atmospheric; A is a tube, the upper end of which is in communication with the interior of V, while the lower end is immersed in mercury contained in a dish C, the surface of the mercury being exposed to atmospheric pressure. The mercury stands at a hight in the tube of 25 inches above the level of the mercury in the dish, so that this 25-inch column of mercury, plus the pressure in the vessel C, balances the atmospheric pressure. There is in this case said to be a 25-inch vacuum in the vessel V.

This method of expressing vacuum is sufficiently good for rough measurements, when the vacuum is not very high, that is, the pressure not very low; but it will be seen that it does not definitely express the pressure, but only the difference between the pressure and atmospheric pressure, and the latter is not constant.

With steam turbines, which benefit greatly by high vacuum, it is desirable to know the absolute pressure in the condenser and at the exhaust end and other places in the turbine, as the temperature of the steam, and likewise the work obtainable from the steam, depend on the

INCHES AND PERCENTAGE OF VACUUM.

Absolute Pressure in Lb. per Sq.In.	Vacuum in Inches of Mercury; Barometer at 30 In.	Percentage Vacuum; Barometer at 30 In.	Absolute Pressure in Lb. per Sq.In.	Vacuum in Inches of Mercury; Barometer at 30 In.	Percentage Vacuum; Barometer at 30 In.	Absolute Pressure in Lb. per Sq.In.	Vacuum in Inches of Mercury; Barometer at 30 In.	Percentage Vacuum; Barometer at 30 In.
0.0000	30.0	100	1.670	26.6	88⅔	6.631	16.5	55
0.0491	29.9	99⅔	1.719	26.5	88⅓	6.876	16.0	53⅓
0.0982	29.8	99⅓	1.768	26.4	88	7.122	15.5	51⅔
0.1474	29.7	99	1.817	26.3	87⅔	7.368	15.0	50
0.1965	29.6	98⅔	1.866	26.2	87⅓	7.613	14.5	48⅓
0.2456	29.5	98⅓	1.916	26.1	87	7.859	14.0	46⅔
0.2947	29.4	98	1.965	26.0	86⅔	8.104	13.5	45
0.3438	29.3	97⅔	2.063	25.8	86	8.35	13.0	43⅓
0.3929	29.2	97⅓	2.161	25.6	85⅓	8.595	12.5	41⅔
0.4421	29.1	97	2.259	25.4	84⅔	8.841	12.0	40
0.4912	29.0	96⅔	2.358	25.2	84	9.087	11.5	38⅓
0.5403	28.9	96⅓	2.456	25.0	83⅓	9.332	11.0	36⅔
0.5894	28.8	96	2.554	24.8	82⅔	9.578	10.5	35
0.6385	28.7	95⅔	2.652	24.6	82	9.823	10.0	33⅓
0.6876	28.6	95⅓	2.751	24.4	81⅓	10.07	9.5	31⅔
0.7368	28.5	95	2.849	24.2	80⅔	10.31	9.0	30
0.7859	28.4	94⅔	2.947	24.0	80	10.56	8.5	28⅓
0.8350	28.3	94⅓	3.045	23.8	79⅓	10.81	8.0	26⅔
0.8841	28.2	94	3.143	23.6	78⅔	11.05	7.5	25
0.9332	28.1	93⅔	3.242	23.4	78	11.30	7.0	23⅓
0.9823	28.0	93⅓	3.340	23.2	77⅓	11.54	6.5	21⅔
1.031	27.9	93	3.438	23.0	76⅔	11.79	6.0	20
1.081	27.8	92⅔	3.684	22.5	75	12.03	5.5	18⅓
1.130	27.7	92⅓	3.929	22.0	73⅓	12.28	5.0	16⅔
1.179	27.6	92	4.175	21.5	71⅔	12.52	4.5	15
1.228	27.5	91⅔	4.421	21.0	70	12.77	4.0	13⅓
1.277	27.4	91⅓	4.666	20.5	68⅓	13.02	3.5	11⅔
1.326	27.3	91	4.912	20.0	66⅔	13.26	3.0	10
1.375	27.2	90⅔	5.157	19.5	65	13.51	2.5	8⅓
1.424	27.1	90⅓	5.403	19.0	63⅓	13.75	2.0	6⅔
1.474	27.0	90	5.648	18.5	61⅔	14.00	1.5	5
1.523	26.9	89⅔	5.894	18.0	60	14.24	1.0	3⅓
1.570	26.8	89⅓	6.140	17.5	58⅓	14.49	0.5	1⅔
1.621	26.7	89	6.385	17.0	56⅔	14.74	0.0	0

absolute pressure, quite irrespective of the pressure of the atmosphere.

The power of custom is, however, so great that engineers still stick to the mode of expressing low pressures as "inches of vacuum," but to enable the absolute pressure to be calculated, it is usual, with low-pressure readings, to mention the hight of the barometer when recording the "inches of vacuum." If the vacuum in a condenser is said to be 28 inches and the barometer to be at 30.4, then we know that the absolute pressure within the condenser is

$$30.4 - 28 = 2.4$$

inches of mercury. Instead of giving the two figures, or two sets of figures, one referring to the vacuum and the other to the barometer, it is common in Great Britain to correct the vacuum reading to apply to a 30-inch barometer and to give the corrected reading only. For example, if the vacuum were 28 inches and the barometer 30.4 inches, the corrected vacuum reading would be

$$28 - (30.4 - 30) = 27.6.$$

The correction can usually be performed mentally. A high vacuum should not be expressed in inches of vacuum without mention being made of the barometric hight, unless a correction for a 30-inch barometer has been made.

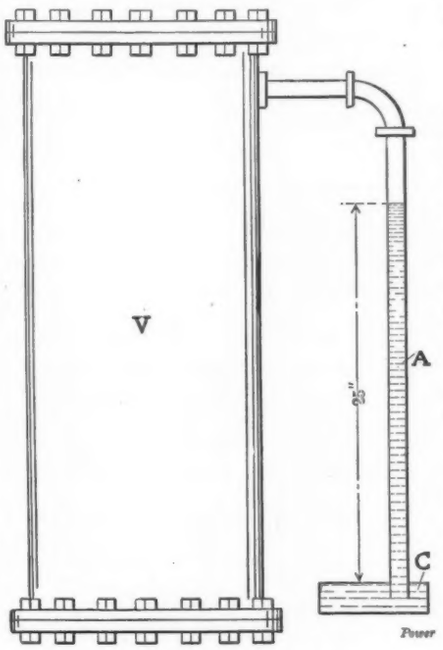
Sometimes vacua are expressed as percentages. If the vacuum is, say, 27 inches with a 29-inch barometer, it is spoken of as a 93.1 per cent. vacuum, 27 inches being 93.1 per cent. of 29 inches. It is often specified in Europe that the steam consumption of a steam turbine must not exceed a certain amount with a certain percentage vacuum. This practice is not, however, to be recommended. A vacuum of 96 per cent., for example, with the barometer at 28 inches represents an absolute pressure of

$$\frac{4}{100} \times 28 = 1.12$$

inches of mercury, or 0.55 pound per square inch; whereas, with a 31-inch barometer, the same percentage of vacuum represents a pressure of

$$\frac{4}{100} \times 31 = 1.24$$

inches of mercury, or 0.594 pound per square inch, a difference of nearly a tenth of an inch of mercury, which will affect the steam consumption of a turbine from a half per cent. to one per cent. When the vacuum in a guarantee of steam consumption is specified as a percentage it will naturally be to the turbine builder's advantage to arrange, if possible, for the official tests to take place under a low barometer.



MEASURING VACUUM IN TANK

In the accompanying table are given the inches and percentage of vacuum, both for a 30-inch barometer, corresponding to pressures from zero to atmospheric pressure. For example, if in a vessel there is an absolute pressure of, say, 1.474 pounds per square inch, a mercury column in communication with the vessel should indicate a vacuum of 27 inches, if the barometer is at 30 inches. If the barometer is not at 30 inches, the mercury column would not indicate 27 inches, but its reading after correction for the barometer would be 27 inches.

It has already been said that the absolute pressure is important in connection with the performance of a steam turbine. The atmospheric pressure, on the other hand, has no effect on the performance except that it may slightly influence the chances of air leakage. With air pumps the case is, however, different. An air pump is affected by the absolute pressure in the condenser, which largely determines the necessary capacity of the pump; it is also, however, affected by the atmospheric pressure which determines, first, the work required to be done in compressing and delivering the air and, second, the effect of reëxpansion of any undischarged air within the pump cylinder. In a steam-consumption guarantee test of a turbine, when the vacuum is specified as a percentage, it was suggested that it was to the advantage of the turbine manufacturer to have the test run under a low barometer. In the case of a guarantee test of an air pump, when the vacuum is specified as a percentage, it will be to the advantage of the air-pump manufacturer—or at least the individual or firm delivering the air pump—to have the test run under a low barometer, because the work of compression and the reëxpansion effect, if any, are both nearly proportional to the ratio of compression, i.e., to the percentage of vacuum; but the amount of air which can be delivered per stroke depends on the admission density of the air which, with a given percentage of vacuum, will be greater with a high than with a low barometer.

Rotary and Other Air Compressors

By F. R. Low

Pokorny & Wittekind, of Frankfort-on-the-Main, Germany, make machines for compressing air and pneumatic tools for using the air after it has been compressed. They use an ingenious arrangement of trunk piston wherein the annular space surrounding the trunk is the high pressure and the other end of the cylinder the low.

The air passes from the low- to the high-pressure cylinder through a vertical U-tube intercooler mounted on top of the cylinder and often the largest feature of the machine which, on account of the absence of piston rod and guides, is very compact. The pistons are packed with cast-iron rings, the joint being made by lapping the ends over a block which has been left in the ring groove, as in Fig. 2.

They were just assembling at the time of our visit a four-stage machine to compress air to a pressure of 1455 pounds gage with exhaust steam of atmospheric pressure. The pressures for the several stages are

37: 162:: 470: 1455.

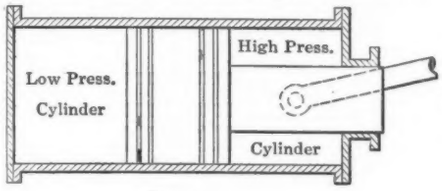


FIG. 1

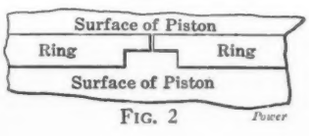


FIG. 2

The power required is 190 horsepower, and the single steam cylinder has a diameter of 44 inches and a stroke of 20 inches. The capacity is 388 cubic feet per minute of free air.

Another and still more remarkable machine was a rotary compressor designed to compress 1,236,000 cubic feet of free air per hour to a pressure of 117.6 pounds in 12 stages. It runs at 4000 revolutions per minute. This is an exceptionally high pressure for a rotary.

High Speed Compound Engine Design

By J. D. Speedium

The complete design, including all computations and working drawings, of a 500-horsepower, high-speed, vertical, compound engine is taken up and represents the latest British practice in this line. The present article carries the design up through the cylinders, and subsequent instalments will take up the other parts of the engine in order.

In this series of articles, the design and construction of a modern high-speed, inclosed, forced-lubrication steam engine is dealt with in every detail, and in such a manner as to clearly demonstrate present-day British practice. Commencing with the specifications for a 500-horsepower engine, the design of the engine is next dealt with and a complete set of working drawings included.

Specifications

The engine is to be capable of developing 500 indicated horsepower, and to carry 25 per cent. overload when supplied with steam at a pressure of 150 pounds per square inch, exhausting into a condenser having a vacuum of 26 inches of mercury, and to run at a speed of 300 revolutions per minute.

Cylinders: The cylinder castings are to be made of hard close-grained cast iron. Each cylinder with its valve box is to be a separate casting, designed to eliminate, as much as possible, distortion due to the temperature of highly superheated steam. Top and bottom covers are to be accurately machined and polished all over the inside surfaces, and clearances are to be reduced to a minimum. The valve boxes are to have liners fitted to them. Relief valves and drain cocks must be of ample size to be fitted. The cylinders and covers are to be covered with a thick layer of nonconducting composition, afterward lagged with planished steel.

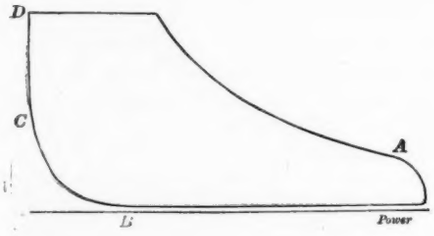


FIG. 1. IDEAL DIAGRAM

The material used must have a tensile strength of not less than 28,000 pounds per square inch, and a bar, 2x1 inch by 3 feet 6 inches, cast from the same ladle, must be capable of withstanding a load of 3800 pounds at the center, when placed upon supports 3 feet apart, and have a deflection at the center of not less than ⅜ inch.

Valves: The valves are to be of the piston type and of cast iron, fitted with solid floating rings having water grooves cut on the face not more than 2 inches apart. The rings must be secured by means of junk plates to allow of the end play being taken up.

Frame or Trunk: The working parts of the engine are to be inclosed in a trunk strongly ribbed and made of cast iron. Doors are to be provided opposite each crank at the front and back of the engine to give easy access to all working parts. The trunk is to be securely bolted to the bed by closely pitched studs so as to make an oil-tight joint.

Bed: The bed is to be of massive design and provided with doors allowing easy access to the oil pump and strainer. The material used for the trunk and the bed must have a tensile strength of not less thar 18,000 pounds per square inch, and the maximum load of the engine must not stress any part more than 500 pounds per square inch.

Distance Piece and Crosshead Guide: Each cylinder is to be carried on a cast-iron distance piece with which must be formed the crosshead guide. This casting must also form the bottom cylinder cover. A separate gland must be fitted at the top of the trunk to prevent leakage of water from the glands getting into the crank chamber. The crosshead guides are to be of the bored form.

Main Bearings: The main bearings are to be of ample size, fitted with cast-iron bushes lined with antifriction metal. The pressure per square inch as calculated from the indicator diagram, when the engine is developing full load must not exceed 200 pounds per square inch on the bearing.

Piston Rods and Crossheads: The piston rods and crossheads must be forged solid and made of Siemens-Martin acid steel having a tensile strength of not less than from 76,000 to 84,000 pounds per square inch, and an elongation of not less than 20 per cent. in 2 inches. The bushes are to be of phosphor bronze and the slippers of cast iron.

Connecting Rods: The connecting rod is to be forged from Siemens-Martin acid mild steel having a tensile strength of not less than from 56,000 to 64,000 pounds per square inch and an elongation of not less than 25 per cent. in 2 inches. It is to be formed with a jaw at the top end, into which a case-hardened crosshead pin will be shrunk. The bottom end is to be fitted with brass bushes lined with antifriction metal.

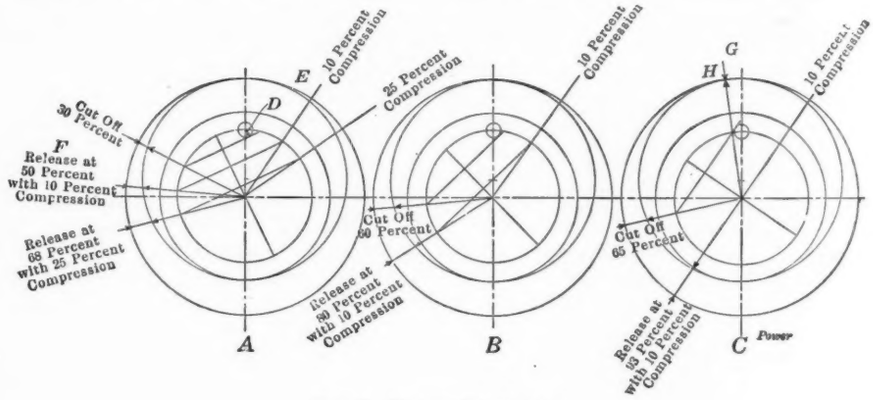


FIG. 2. VALVE DIAGRAMS

Valve Gear: The valves are to be operated direct from the crank shaft by means of eccentrics, the eccentric straps being lined with antifriction metal. The eccentric-rod pins must be case-hardened, and the valve-spindle crossheads fitted with adjustable brasses.

Pistons: The high-pressure piston is to be of cast iron, and the low-pressure piston of wrought steel having a tensile strength of not less than from 76,000 to 84,000 pounds per square inch.

Crank Shaft: The crank shaft is to be forged solid with the cranks placed at 180 degrees, of Siemens-Martin acid steel having a tensile strength of not less than 56,000 to 64,000 pounds per square inch and an elongation of not less than 27 per cent. in 2 inches.

Flywheel: The flywheel is to be of plate form, solid and of cast iron, having a tensile strength of not less than 18,000 pounds per square inch. It is to be left a tight fit and forced onto the crank shaft by hydraulic pressure. The weight

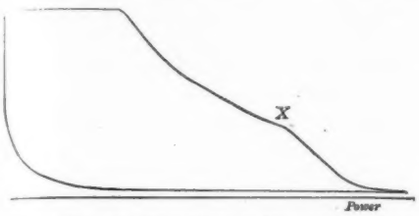


FIG. 3. TOO EARLY RELEASE

of the rim is to be such that the cyclic variation does not exceed 1/500. A rack is to be cast in the rim so that the engine may be barred round in either direction.

Governor: The governor is to be of the centrifugal type fixed on the crank shaft, and acting, as directly as possible, upon a throttle valve; the throttle valve to be of the double-seated balanced type.

Lubrication: This is to be of the forced type, all parts, including the governor, to be automatically lubricated from a valveless pump driven from one of the eccentrics actuating the valves.

The first points to decide are the size of cylinders. Actual experience has shown that the most economical size of cylinders for any given power is less than what would be expected from purely theoretical considerations. The most economical mean effective pressures for various steam pressures for simple-, compound- and triple-expansion engines both condensing and noncondensing are given in Table 1.

TABLE 1. ECONOMICAL MEAN EFFECTIVE PRESSURES.

Pressure in Pounds per Square Inch.	Simple Engines.		Compound Engines.		Triple-expansion Engines.	
	Condensing.	Non-condensing.	Condensing.	Non-condensing.	Condensing.	Non-condensing.
50	26	30				
75	31	35	27	29		
100	36	40	30	34		
125			34	39	29	36
150			38	44	32	40
175			40	49	34	44
200			42	54	37	48

In the present instance the pressure being 150 pounds per square inch and the engine running condensing, the most economical mean effective pressure will be 38 pounds, referred to the low-pressure piston. The area of the cylinder may now be found by the following formula:

$$A = \frac{I.H.P. \times 33{,}000}{M.E.P. \times P.S.}$$

where,

A = Area of low-pressure piston,
$I.H.P.$ = Indicated horsepower of the engine,
$M.E.P.$ = Mean effective pressure,
$P.S.$ = Piston speed.

The piston speeds usually allowed in practice are given in Table 2.

TABLE 2. PISTON SPEEDS.

Horsepower of Engine.	Speed in Revolutions per Minute.	Piston Speeds in Feet per Minute.
		Not exceeding
50 to 200	600 to 500	650
200 to 500	500 to 325	750
500 to 1000	375 to 250	800
1000 to 3000	300 to 175	800 to 1000

In the present case the piston speed may be taken at 700 feet per minute and the area of the low-pressure cylinder will be

$$\frac{500 \times 33{,}000}{38 \times 700} = 620 \text{ square inches}$$

which represents approximately 28 inches diameter; and as the piston speed is 700 feet per minute, the stroke will equal

$$\frac{700}{(2 \times 300)} = 1.16 \text{ feet}$$

say, 14 inches stroke. The size of the high-pressure cylinder must now be found. The ratio of high- to low-pressure cylinders must be such that the cutoff in the high-pressure cylinder is about 0.6 of the stroke, when the engine requires nearly boiler pressure, about 145 pounds, to develop the maximum load. To fix the ratio of cylinders it is necessary to determine the number of times the steam must be expanded to give a mean effective pressure of 38 pounds under normal conditions and 47.5 pounds at 25 per cent. overload.

By referring to a steam-expansion table and allowing for a back pressure in the cylinders of three pounds and a diagram factor of 72 per cent., the number of expansions will be found to be 6½. This may be easily checked by the following formula:

$$M.E.P. = \frac{P \times (1 + hyp.\ log\ R) \times D}{R} - B$$

where,

$M.E.P.$ = Mean effective pressure,
P = Absolute pressure in pounds per square inch,
R = Number of expansions,
D = Diagram factor for type of engine as follows:

Simple engines.....78 per cent.
Compound engines.....72 per cent.
Triple-expansion engines...65 per cent.

B = Back pressure in pounds per square inch.

In the present example
$M.E.P.$ = 47.5 pounds,
P = 145 + 15 = 160 pounds absolute,
D = 72 per cent.,
B = 3 pounds,

and,

$$\frac{1 + hyp.\ log.\ 6\frac{1}{2}}{6\frac{1}{2}} = 0.44;$$

therefore,

$(160 \times 0.44 \times 0.72) - 3 = 47.6$ pounds

as the mean effective pressure required.

Taking the mean cutoff in the high-pressure cylinder at 61.5 per cent. of the stroke and allowing for a ratio of expansion of 6.5, as already determined, it will be found that a ratio of cylinder areas of

$$0.615 \times 6.5 = 4 \text{ to } 1$$

will be required. The diameter of the high-pressure cylinder will therefore be 14 inches.

It may appear, at first sight, that the cutoff arranged for is very late in the

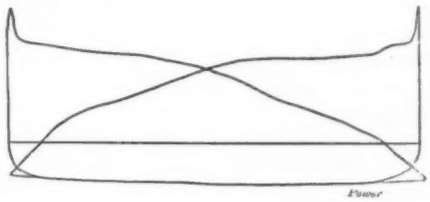


FIG. 4. BEFORE ADJUSTING VALVE SETTING

stroke to give an economical engine, but that is not the case, and as the valve setting is of vital importance if maximum economy is desired, this question will be dealt with at some length.

THE INDICATOR DIAGRAM CONSIDERED IN CONNECTION WITH VALVE SETTING

The valves of an engine if carefully set by an experienced engineer will, as a rule, produce a reasonable indicator diagram.

The indicator diagram which corresponds most closely to the theoretical figure is usually looked upon as the most perfect, and the setting which produces this result is regarded as the ideal one. This is correct to a certain extent, and is applicable to engines having separate steam and exhaust valves, but where only one valve is used for both steam admission and exhaust, the best looking diagram does not always give the best results.

Providing a valve setting gives a good running engine without knocks or pounding, the most important point to consider is economy in steam consumption. Consider for a moment the elementary points in connection with the steam distribution to an engine cylinder.

In Fig. 1 is shown what would be called an ideal diagram from a simple noncondensing engine. If the cylinder has separate valves for steam and exhaust (as in a Corliss engine for instance, with the valves driven through a

wristplate) giving efficient opening and closing to valves, it is not difficult to produce a very similar diagram. Steam can be admitted just before the piston arrives at the end of the stroke, and as a quick opening is given to the valve by

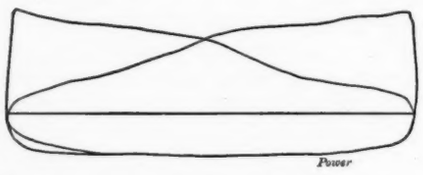


FIG. 5. AFTER ADJUSTING VALVE SETTING

the wristplate, there is no difficulty in obtaining a good steam line closely approximating to the boiler pressure right up to the point of cutoff, when, owing to the almost instantaneous closing of the valve, a sharp corner is obtained. Again, the expansion may be carried to almost the very end of the stroke, and the exhaust valve then opened quickly to save loss due to back pressure or excessive rounding of the corner at *A*. When the clearance volume is small, compression need not commence before the point *B* shown on the diagram, and with a small lead, as already referred to, the vertical line *C D* giving full pressure at the commencement of the stroke is easily obtained.

It should be noted here that the best results as regards economy are always

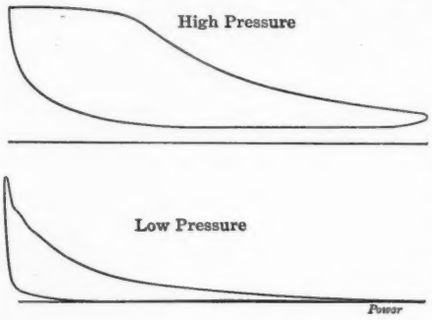


FIG. 7. LATE RELEASE IN DROP-VALVE TYPE OF ENGINE

obtained by expanding the steam to a fairly large degree, and even in compound and triple-expansion engines with cylinders of high ratio, these results can be btained only when cutting off steam early in the stroke. Early cutoff, combined with a late release, can very conveniently be arranged for in two-valve

used. Fig. 2, *A*, *B* and *C* represent such diagrams. In *A* steam is cut off at 30 per cent. of the stroke, giving the engine a small lead of ¼ inch as shown at *D*, and the angle of the eccentric is at once fixed. Owing to the small clearance volume, it is not advisable to commence compression before 90 per cent. of the stroke has been open to exhaust, as at *E*. This, therefore, fixes the point of release as shown at *F*. Hence, release occurs at 50 per cent. of the stroke, which is very uneconomical, and has the effect of producing an indicator diagram as shown in Fig. 3. Here the release takes place at *X*, and the pressure almost immediately falls, and for the remainder of the stroke little or no work is done by the steam in the cylinder. Comparing the diagram in Fig. 3 with that shown in Fig. 1 it will be readily seen that far more work is obtained from the same quantity of steam by the distribution shown in Fig. 1.

By making the cutoff later, better results as regards release can be obtained, as shown in diagram *B*, Fig. 2. In this diagram the cutoff is shown as taking place at 60 per cent. of the stroke, but even here the release takes place at 80

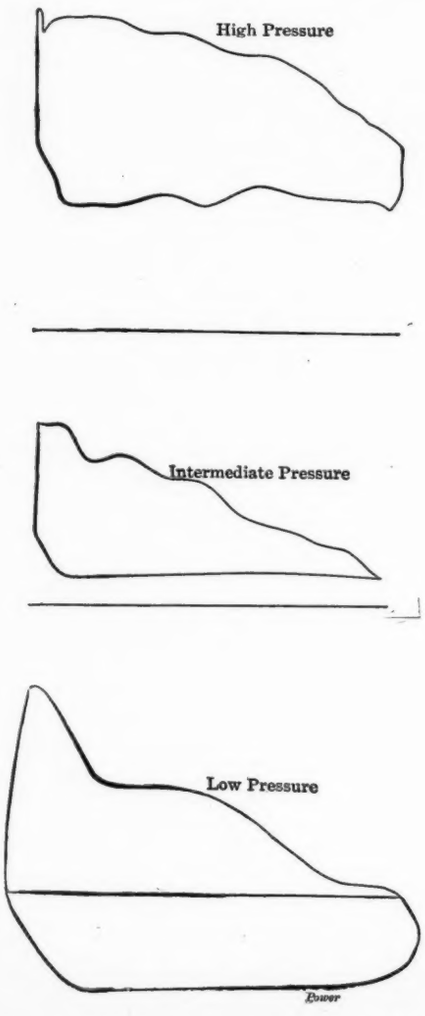


FIG. 6. DIAGRAMS SHOWING LACK OF LEAD

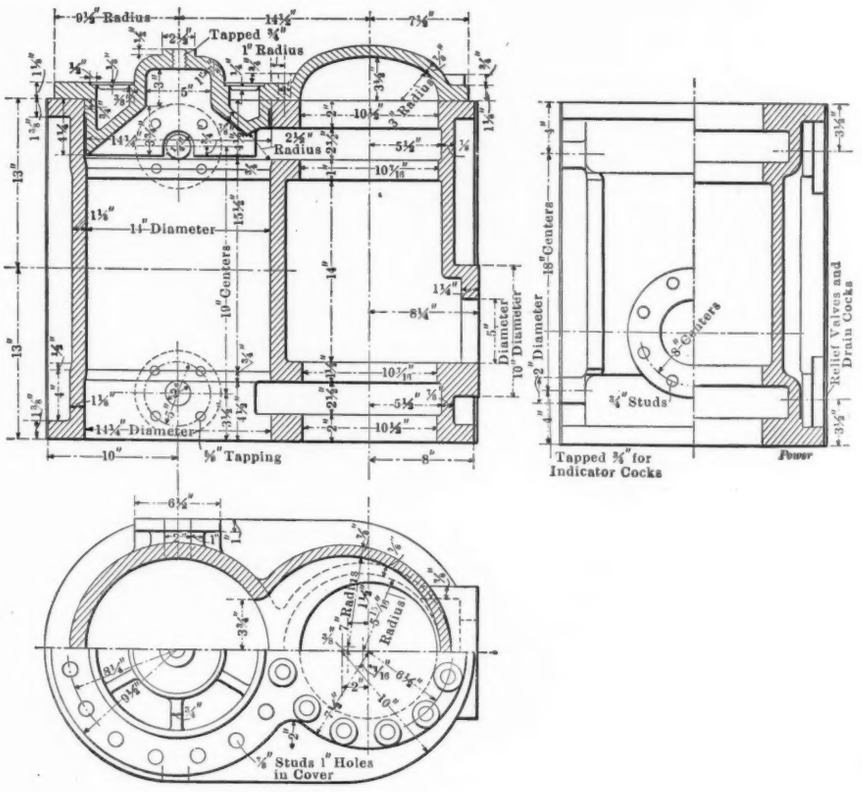


FIG. 8. HIGH-PRESSURE CYLINDER

engines, but not so in the case of single-valve engines when driven by an eccentric.

This point may be best illustrated by means of a valve diagram, and for this purpose the Zeuner diagram, combined with a crank and piston diagram, will be

per cent. of the stroke, if compression is arranged for 10 per cent. This brings us to an important point—Is it advisable to produce a good admission line at the commencement of the stroke by giving a lead to the valve, or is it beneficial to sacrifice lead in favor of release? This

point is not as fully understood as it might be, but owing to the necessity of obtaining maximum economy with high-speed engines, which are all of the single-valve type, driven by eccentrics, it has been fully considered by the builders of those engines, particularly in England.

Diagram *C*, Fig. 2, shows what can be done in this direction. In this diagram the cutoff takes place at 65 per cent. of the stroke, and compression at 90 per cent., but owing to the alteration in the lead of the valve a release at 93 per cent. is obtained. By giving a negative lead to the valve it may be argued that a loss takes place at the commencement of the stroke, but against this must be placed the late release and consequent gain at the end of the diagram.

Actual results are always the best guide and it has been found by experience that considerable advantage is gained by modifying the valve setting similar to that shown in *C*, Fig. 2. It should be noticed that although admission does not commence until *G* is reached by the crank, the piston has moved only through a distance *H* or about 2 per cent. of the stroke.

In confirmation of the above arguments, indicator diagrams are shown in Fig. 4, taken from a high-speed engine of English make with lead given to the valves and consequently early release. In Fig. 5 is shown a set of diagrams from the same engine with valve settings altered to give results similar to those shown in valve diagram *C*, Fig. 2. By altering the setting from Fig. 4 to Fig. 5 a saving of 10 per cent. in steam consumption was obtained.

In Fig. 6 is shown a set of indicator diagrams taken from a triple-expansion high-speed engine. The lack of lead is again very noticeable, but a good release is shown, which no doubt compensates for any defect in the steam-admission line.

There is no doubt that the economical performances of the Corliss drop-valve engine and the drop-piston-valve engine are largely due to the efficient distribution of the steam, and a comparison between the distribution of steam in the various types is therefore instructive. In drop-valve engines the advantages of late release are at once discernible by referring to Fig. 7, which shows a set of diagrams taken from a Sulzer engine. Corliss engines having their valves driven in a similar manner give equally good results.

The details of the valve setting for the engine under consideration will be dealt with fully when dealing with the piston valves.

Cylinders

The design of the cylinders may now be proceeded with. In Figs. 8 and 9 are shown detail drawings of the high- and low-pressure cylinders respectively. It will be noticed that they are of very simple design, and as both top and bottom covers are separate, the cylinder casting itself is a very plain one.

The speeds through the inlet and exhaust passages, steam ports, etc., as used in this design, represent current practice. High-pressure cylinder, 6000 feet per minute; intermediate-pressure cylinder, 7000 feet per minute; low-pressure cylinder, 8000 feet per minute.

The speed through the ports of low-pressure cylinders of compound engines

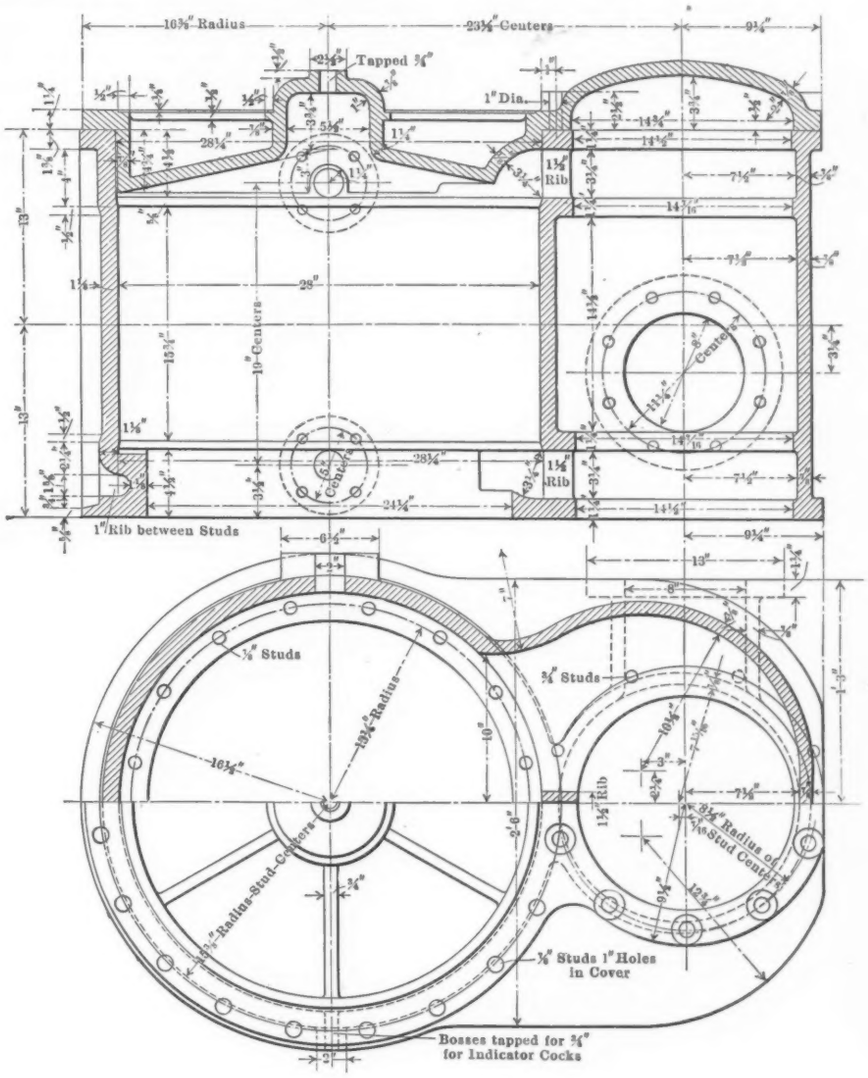


FIG. 9. LOW-PRESSURE CYLINDER

The size of the steam inlet to the high-pressure cylinder should be such that the velocity does not exceed 7000 feet per minute and the exhaust 5000 feet per minute. The inlet to the low-pressure cylinder must be arranged to suit a velocity not exceeding 9000 feet per minute, and the final exhaust from this cylinder should not exceed 5400 feet per minute. The sizes may be found by the formula,

$$\frac{P.S. \times A}{V} = \textit{area of pipe or port in square inches}$$

where,

$P.S.$ = Piston speed in feet per minute,

V = Velocity of steam in feet per minute,

A = Area of cylinder in square inches.

The area of the steam ports may be fixed by this rule, but the following speeds of steam should not be exceeded: is taken as for intermediate cylinders of triple-expansion engines.

The steam inlet of the high-pressure cylinder must therefore equal

$$\frac{700 \times 153.9}{7000} = 15.39$$

square inches, approximately 4½ inches diameter, the nearest even size being 5 inches diameter.

The exhaust equals

$$\frac{700 \times 153.9}{5000} = 21.5$$

square inches or approximately 5¼ inches diameter. As, however, the size of the exhaust from the high-pressure cylinder is usually made the same diameter as the inlet to the low-pressure cylinder, this must be determined as follows:

$$\frac{700 \times 615}{9000} = 47.8$$

square inches, representing a diameter of about 7¾ inches, say, 8 inches. This is therefore the diameter of the high-pressure exhaust and the low-pressure steam inlet.

The area of the steam ports of the high-pressure cylinder must be

$$\frac{153.9 \times 700}{6000} = 17.9 \text{ square inches.}$$

The area of the steam ports of the low-pressure cylinders will require to be

$$\frac{700 \times 615}{7000} = 61.5 \text{ square inches}$$

and the exhaust pipe

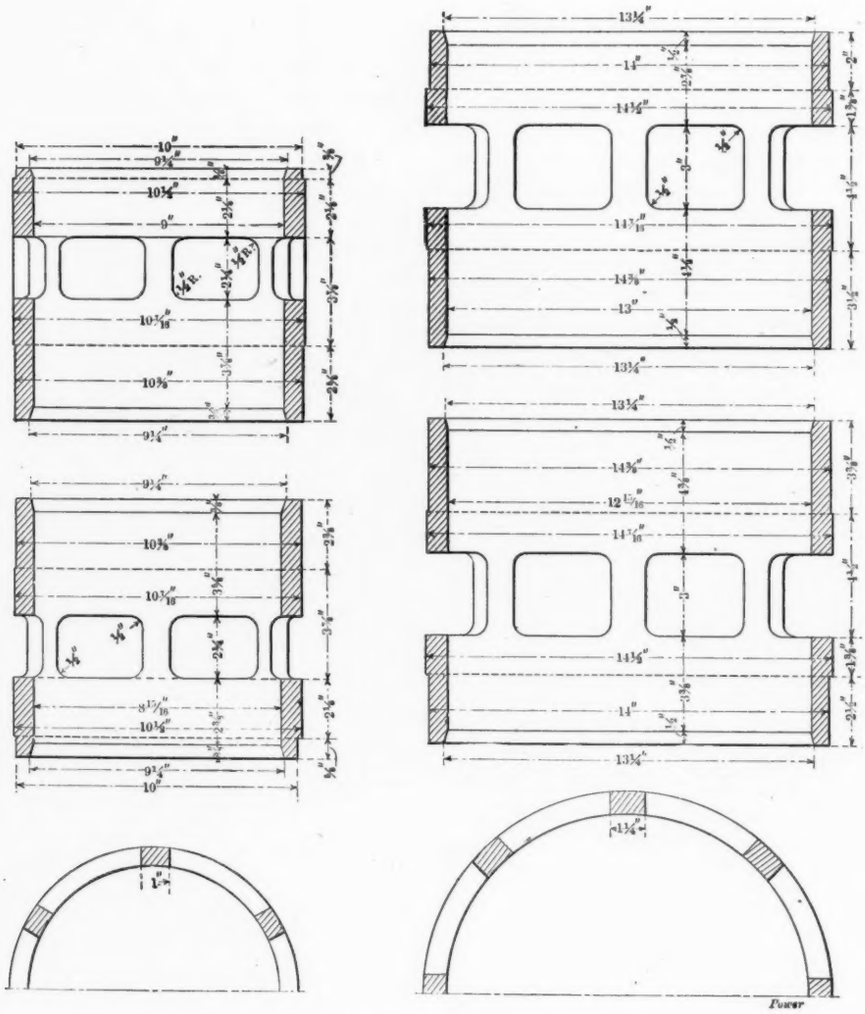


FIG. 10. HIGH- AND LOW-PRESSURE VALVE-CHEST LINERS

$$\frac{700 \times 615}{5400} = 79.7 \text{ square inches,}$$

representing a diameter of approximately 10 inches as a minimum.

In designing the cylinders, the barrel should be kept as free from ribs and as independent of the other parts of the cylinder as possible, particularly in the case of high-pressure cylinders where superheated steam is used. This is with a view to preventing distortion due to unequal expansion of the various parts of the casting at high temperature.

The clearances call for special attention in high-speed engines, owing to the shortness of the stroke. This point will be clearly realized when it is considered that in the case of a slow-speed engine, of the power under consideration, the speed would be about 80 to 90 revolutions per minute, or one-fourth the speed of the high-speed engine. As the piston speed would be about the same, or probably slightly less, it will be seen that the stroke would be about four times that of the high-speed engine. Assuming, therefore, that the steam ports are made the same area in each case, and the clearance between the cover and the piston at the end of the stroke is the same, the total clearance volume would remain the same. Taking the clearance volume of the slow-speed engine at 5 per cent. of the cylinder volume, under similar conditions it would be 20 per cent. of the high-speed engine cylinder volume, and in case of the high-speed engine any loss due to clearance would take place four times as often. Under ordinary conditions it is rarely possible to make the clearance less than from 10 to 12 per cent. It should be noted that in the case of high-speed engines, only one port is used for both steam and exhaust, whereas in the case of slow-speed engines the steam is usually admitted and exhausted by separate ports.

The ports must therefore be made very short and straight, the joints of the cylinder cover and valve-chest cover generally fixing the length. As will be seen by referring to the drawings, Figs. 8 and 9, in order to reduce the length of the ports to a minimum, the cylinders and valve-chest covers are cast together. The bottom covers are formed with the casting which carries the cylinders, and the same casting is also extended into the frame to form the crosshead slides.

The general dimensions of the cylinders are fixed by the design of the piston and the valves adopted. These details will be considered separately. It will be noted that liners are fitted to the valve chests, but not to the cylinder barrel. Liners are rarely used for the barrel, and as experience has shown that steam jacketing is useless in this class of engine, there is no necessity for fitting them if the cylinder casting is made of hard close-grained metal. The addition of a liner would also slightly increase the length of the steam ports.

The valve-chest liners are shown in detail in Fig. 10. They are usually made of the same metal as the cylinders, and are forced into place, being finally finished when fitted into the cylinder. No other method of securing them has been found necessary.

The length of the cylinders is determined by the stroke and the type of piston, the clearance between the piston and the covers being kept as small as practicable. In all engines of this class it is usual to machine either the inside of the covers or the faces of the pistons. The clearance allowed varies from ⅛ to ¼ inch according to the size of engine. Relief valves of ample size are usually fitted to the cylinders, Table 3 representing the practice generally followed.

TABLE 3. SIZES OF RELIEF AND DRAIN VALVES.

Diameter of Cylinder, Inches.	Diameter of Relief Valve, Inches.	Diameter of Drain Valve, Inches.
12	1¼	⅝
16	1½	⅝
20	1¾	⅝
24	2	¾
30	2½	¾
36	3	1
48	3½	1¼
60	4	1½

The cylinders are lagged with magnesia or asbestos nonconducting material, which is again covered by sheets of planished steel in the usual way, a thickness of from 1½ to 2 inches being allowed for the nonconducting material.

It will be noticed on referring to the high-pressure cylinder drawing that very

little steam-chest capacity is allowed for, as the throttle-valve box is bolted direct to the cylinder. This, however, is beneficial for governing, as the steam between the throttle valve and the cylinder is beyond the control of the governor. The same remarks also apply to the steam chest of the low-pressure cylinder.

Owing to the great loss of heat due to radiation and conduction, the most efficiently designed cylinder is the one which occupies the smallest cubical capacity, other things being equal. This feature will be noticed by referring to Figs. 8 and 9, the flanges being only just large enough for sufficient lagging.

In the case of small compound engines up to about 300 brake horsepower, the high- and low-pressure cylinders are frequently cast together with the piston-valve chamber between them, one piston valve distributing the steam to both cylinders. The valve really consists of two valves placed one above the other. This system is applicable only to engines with cranks opposite one another; that is, placed at 180 degrees.

Peculiar Design of Corliss Engine

In one of the steam plants of Augusta, Ga., is a vertical steam engine of a design not frequently met with. It is of about 850 horsepower capacity, has a cylinder 42x42 inches, and runs at a speed of 72 revolutions per minute. Fig. 1 shows the general appearance of the engine, while Fig. 2 is a near view of the valve gear. It may be seen from Fig. 1 that the engine was originally built for reversing, but one of the eccentric rods has been removed, so that the engine now runs in but one direction. The exhaust valves are shown next to the side of the cylinder connecting with the pipe running to the condenser, which is placed on the roof.

Referring to Fig. 2, it may be seen that the stem of the governor, which is located below the platform of the engine, has a protruding stem, to which is attached an arm running to and pivoted on the frame of the engine; another section extends back over the top of the governor stem. On the inner side of this attachment is an extension, and, when in proper position, comes in contact with

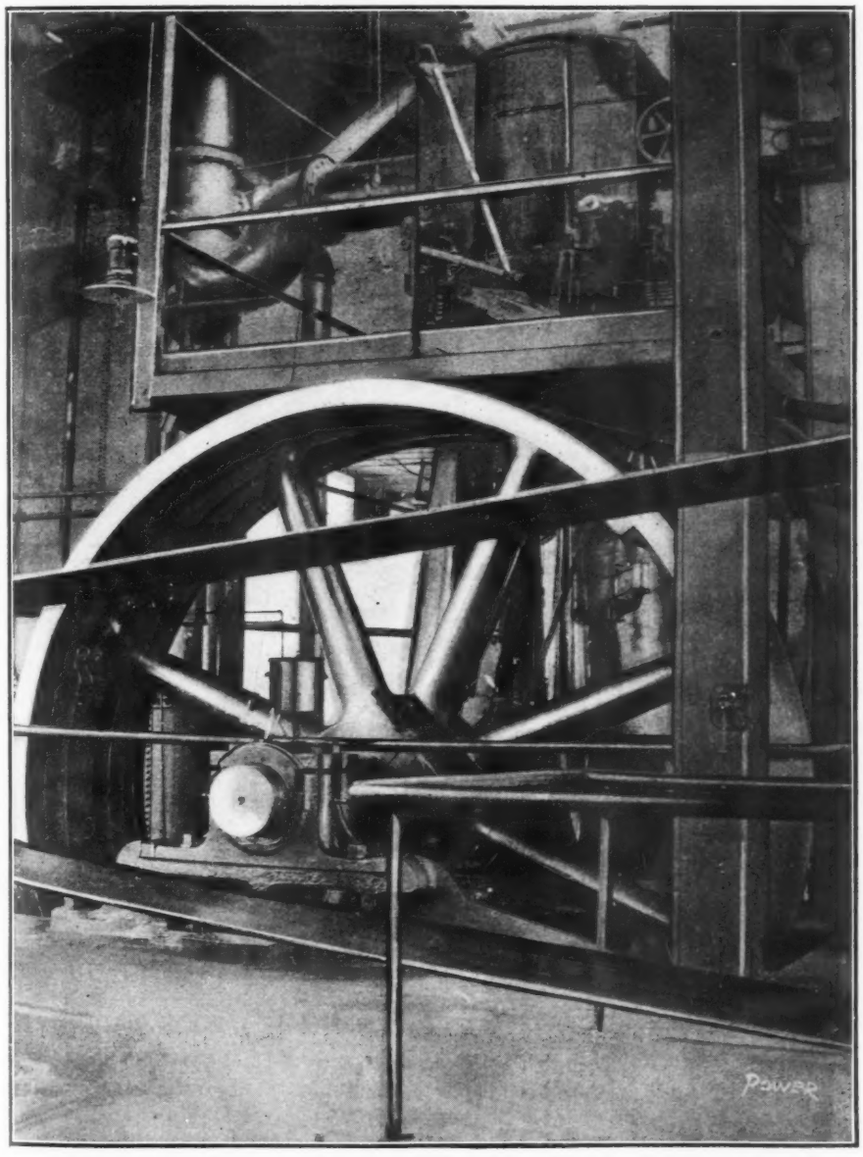


FIG. 1. ODD DESIGN OF VERTICAL ENGINE

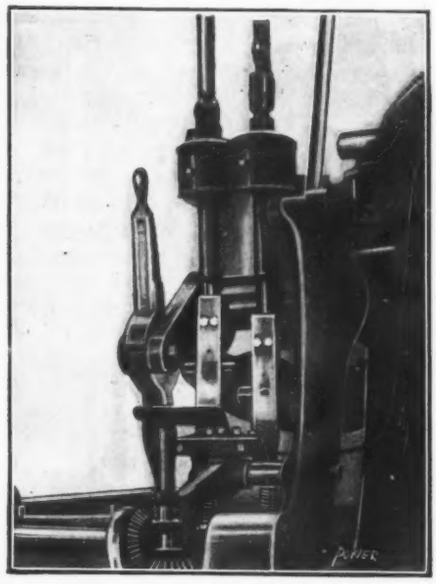


FIG. 2. VALVE GEAR

the trip arms, which are pivoted at a point about the center. The upper ends are fitted with trip blocks, while the lower ends curve out toward the governor. On the valve stems, which extend down below the dashpots, are fitted catch blocks which engage with those secured to the trip arms.

When the engine is in operation the governor stem rises; this lifts the connecting levers and forces the trip plate on the inner side to take a lower position. When it reaches the proper point it comes in contact with the curved ends of the trip arms, forcing them in at the bottom end and out at the top. This releases the catch blocks and the valve is then closed by the action of the dashpot.

Gas Power Department

Practical Points in Operating a Producer

A writer in the *Mechanical World* gives the following rather elementary but very sensible suggestions for the starting and care of a gas producer.

Before starting the fire, see that the generator is shut off from the scrubber and that the purge pipe is open. Lay the fire, using coke to start with, on a layer of ashes reaching above the air grate [?] and having lit it, close and seal the fire door when the fire is well established. Start the blower gently, and gradually build up the fire until the fuel bed is about 3 feet thick. When the fire has burnt up fairly red, turn a little steam into the air supply and apply a light from time to time to the testing cock on the generator outlet pipe. As soon as it will light, turn the gas through the scrubber, but not before, as it is no use putting dirt from bad gas into it. Burn the gas off from the dry purifier, making sure first that it is shut off from the holder, if one is used, or the engine main, if not. Gradually turn steam into the fire until the air at intake is about 60 degrees Centigrade, and take a gas sample from the sawdust scrubber. If it contains about 23 per cent. of CO and 16 per cent. of H, turn the gas into the holder or engine main and start the engine, but burn off the excess of gas at the scrubber of a pressure plant until the engine is well under load and the blower is regulated for a continuous supply.

You can then settle down for a week or so to determine the conditions throughout the plant which best suit the coal you are using. The composition of the gas should be approximately 4 per cent. of CO_2, 25 per cent. of CO, 16 per cent. of H, and as much CH_4 as you can get. To obtain this result you must ascertain the best thickness of fire, the best temperature for the blast (of a pressure producer) and the quantity of coal required per hour. The secret of success lies in finding out these conditions and keeping rigidly to them.

A measured quantity of coal should be fed in at regular intervals of not more than a quarter of an hour. The right amount of ashes should be withdrawn from the bottom also at regular intervals, and the fire well poked down solid after each withdrawal, care being taken that no holes are left through the fuel bed. Gas analyses must be taken frequently until the right steam supply is obtained for the required composition. If the percentage of CO is too low, reduce the amount of steam going into the fire. The best temperature for the blast of a pressure producer may be anywhere between 45 and 65 degrees Centigrade, according to the particular coal used.

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men.

Having once obtained the composition required, make a note of the temperatures throughout the plant, the pressures as shown by the water gages, the hight of the fire and the quantity of coal required per charge. If these conditions are maintained, the quality of the gas will be uniform hour by hour. The temperature of the gas as shown by the pyrometer or the first thermometer after the generator will be found to be an unfailing indication of the state of the fire. If it varies, it will be found that the air or steam or coal has varied, or that clinker has formed in the fire. Observe that every time a fresh coal is tried the necessary conditions must be determined afresh, but once found, the chemical analysis can be discontinued, though an occasional test for CO_2 is useful, especially if the temperature of the gas has risen appreciably.

Bollinckx Producer and Engine

The accompanying engravings illustrate very clearly the principal features of construction of the suction anthracite gas producer and single-acting engine built by A. Bollinckx, Brussels, Belgium. The generator is of the usual up-draft class, but differs in several important details from American practice. The gases are taken from the fuel bed by a central collecting cone located above the active

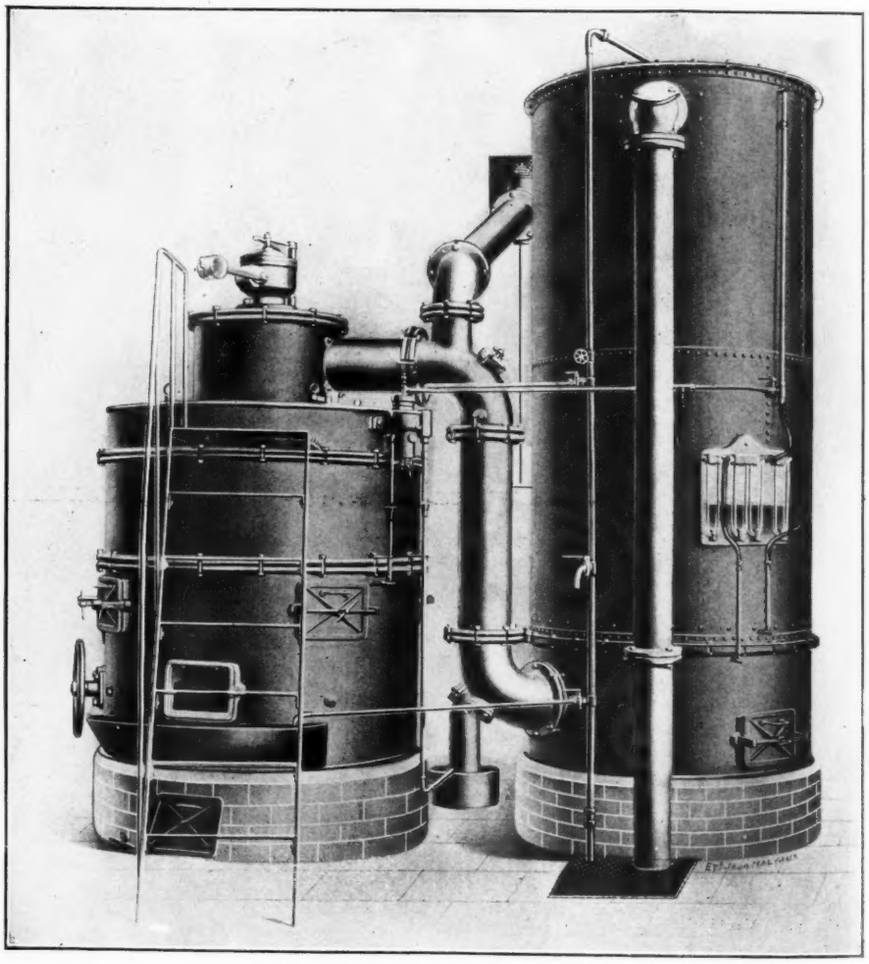


FIG. 1. BOLLINCKX SUCTION GAS PRODUCER

zones of the bed, but surrounded by the green fuel, which therefore absorbs some of the sensible heat from the outgoing gases. This has two useful effects, that of reducing the temperature of the gases, and, consequently, the quantity of cooling water required in the scrubber; and that of reducing the amount of heat that must be supplied to the fuel later in order to distil the volatiles out of it, which means that the incandescent zone does not need to supply quite so much heat as it otherwise would.

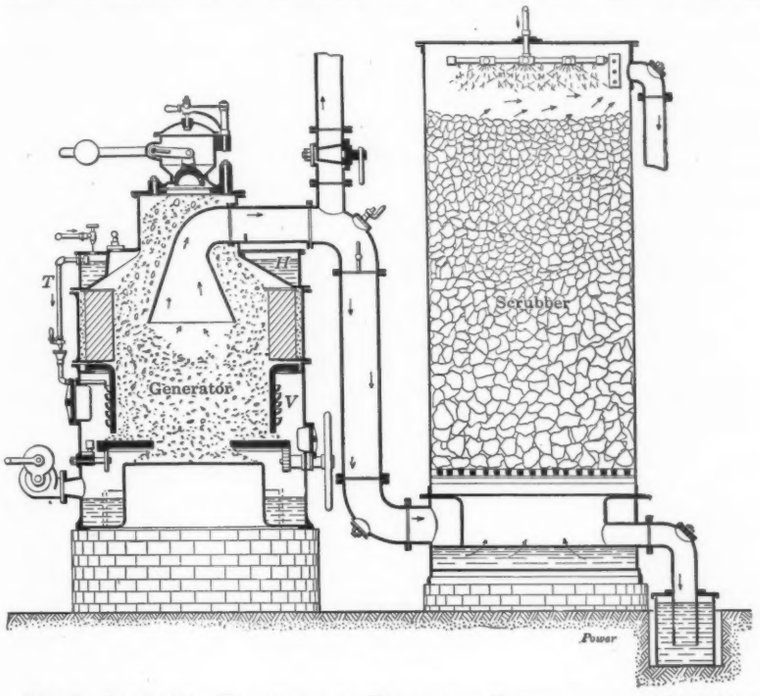


FIG. 2. SECTIONAL ELEVATION OF BOLLINCKX GENERATOR AND SCRUBBER

The vaporizer proper consists of a shallow spiral trough *V*, Fig. 2, around the outside of the cast-iron wall surrounding the incandescent zone, but before the water is delivered to the trough it is warmed in a deep pan *H* built in the top of the generator. From this pan it overflows into the outside pipe *T* whence it drops into a short leader through which it passes to the upper trough of the spiral. This arrangement of feed pipes is employed in order to maintain a constant volume of water in the preheater and to enable the attendant to observe the flow of water, or stoppage of it, from the heater to the vaporizer.

The grate is perfectly flat and rests on rollers mounted on studs set into the ashpit wall. A rack is formed around the edge of the under side of the grate and this meshes with a pinion on the shaft of the wheel by means of which the grate is revolved to shake down the fuel bed. The ashpit is "floored" with a pool of water which extends through an opening in one side of the shell into a trough on the outside; the outline of the opening is shown in the sectional view, and the trough outside of it is shown in Fig. 1. Presumably, this arrangement is to permit raking out ashes while the generator is in service. The ashpit door is left open during operation, the air for the fire entering there.

The generator is provided with the usual hand blower for starting the fire and purge pipe for getting rid of the "green" gases and smoke resulting therefrom. Instead of the more common three-way valve at the junction of the purge pipe and the gas-delivery pipe, Mr. Bollinckx uses a stop valve in the purge pipe and a damper form of valve in the delivery pipe; the method of using these is too obvious to require description.

The scrubber is the familiar coke-filled tower, with a water spray at the top and a sump alongside the foundation. As Fig. 1 shows, a gage board is mounted on the side of the scrubber carrying gages which indicate the pressures in the bottom of the scrubber, just below and above the "grate," at the top of the scrubber, and in the gas pipe leading from the scrubber to the engine. No dry purifier is used.

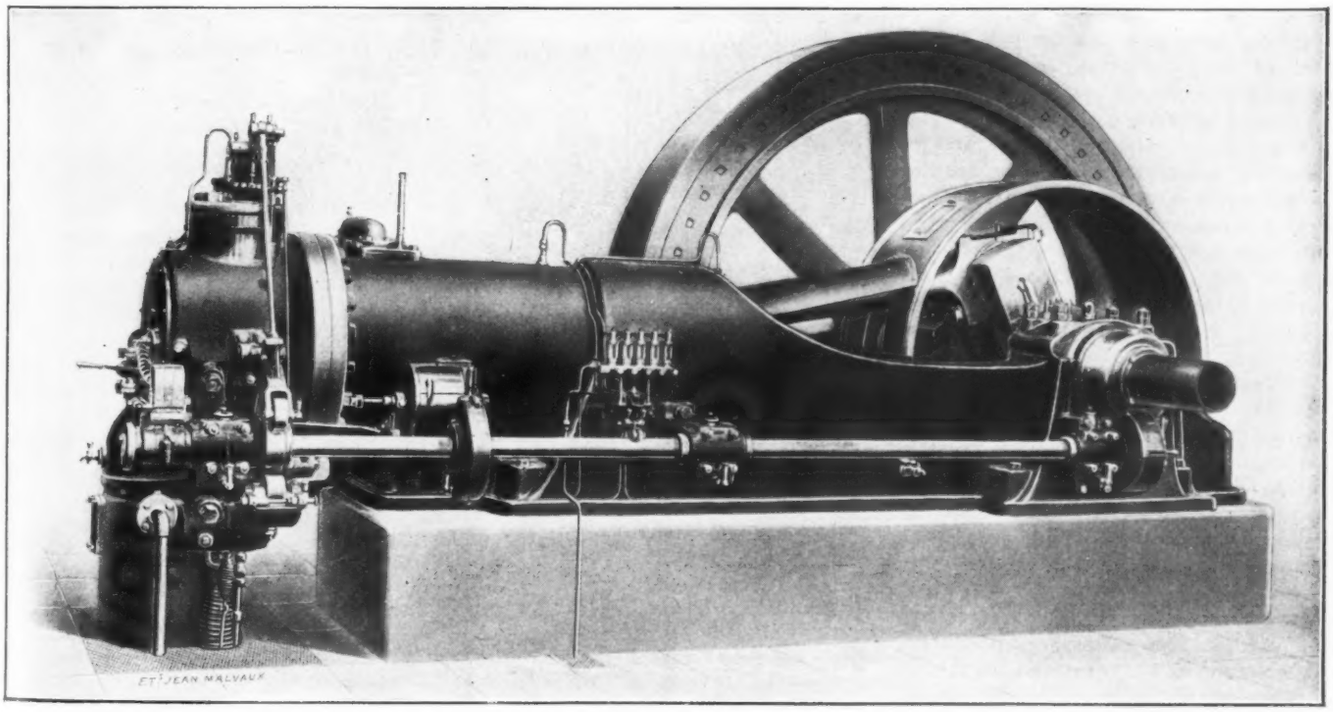


FIG. 3. BOLLINCKX SINGLE-ACTING FOUR-STROKE ENGINE, WITH QUANTITY REGULATION

The engine, as Fig. 3 indicates, is of massive design. The external cylinder wall is cast in one piece with the main

frame; the inner wall is a liner, with flanges fitting in the outer wall at both ends and the middle, and the combustion chamber is formed in the cylinder head, which is bolted to the outer barrel. The piston is unusually long with respect to its diameter, with the gudgeon pin set almost in the center of its length, and the length of the connecting rod is between five and six crank lengths.

The inlet valve is set in a removable cage and the exhaust-valve stem works in a removable sleeve but its seat is integral with the combustion-chamber wall. As Fig. 4 shows, the combustion chamber flares gradually out to the diameter of the cylinder bore, so that pockets, corners and abrupt angles are obviated.

Speed regulation is effected by varying the quantity of mixture admitted, and the governor accomplishes this by inserting a thin wedge more or less between a cam and a roller on coöperating members of the valve gear, thereby varying the opening of the inlet valve; the farther the wedge is inserted, the wider is the valve opened. From Fig. 3 it may be seen that both the inlet and exhaust rockers are worked by a single cam. The other features of the valve gear are so clearly shown in Figs. 3, 4 and 5 as to require no explanation.

The ignition system comprises a high-tension magneto which delivers an impulse of current to a jump-spark plug set in the center of the cylinder head. The magneto armature is oscillated momentarily by a trigger actuated from the cam shaft at the proper instant; between ignitions the armature is stationary.

The exhaust pipe is water jacketed from the combustion chamber down to a point beneath the floor level in order to protect the attendant from accidental contact with the pipe. The jacket is provided with two handholes (see Fig. 5) for inspection and cleansing purposes.

Lubrication of the piston, valve stems and gudgeon pin is accomplished by means of a force-feed oiler, the pump of which is actuated by a cam on the secondary shaft (which the retoucher has carefully painted out in Fig. 3). The oil cup shown at the front end of the cylinder barrel in Fig. 4 is no longer used; this sectional drawing was made before the oil cup was displaced by a feed from the pump.

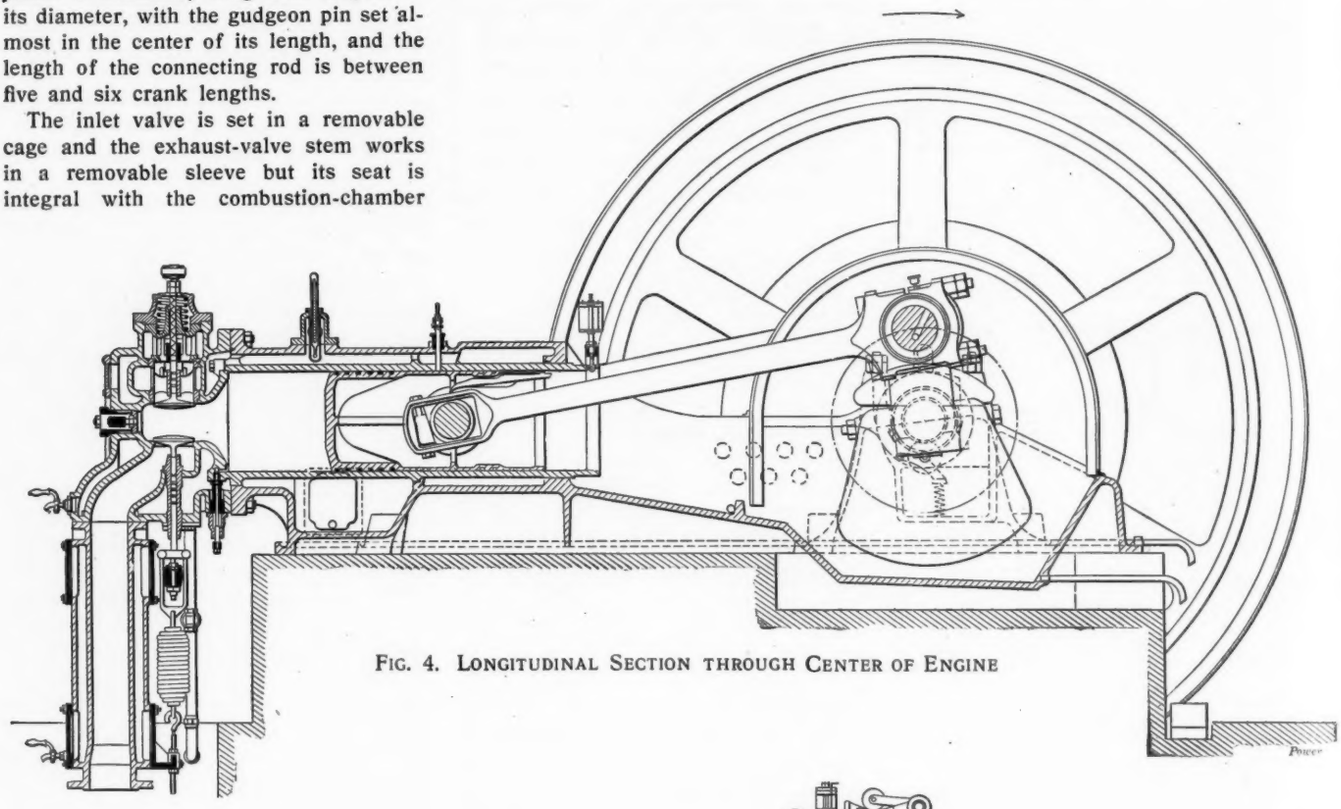


FIG. 4. LONGITUDINAL SECTION THROUGH CENTER OF ENGINE

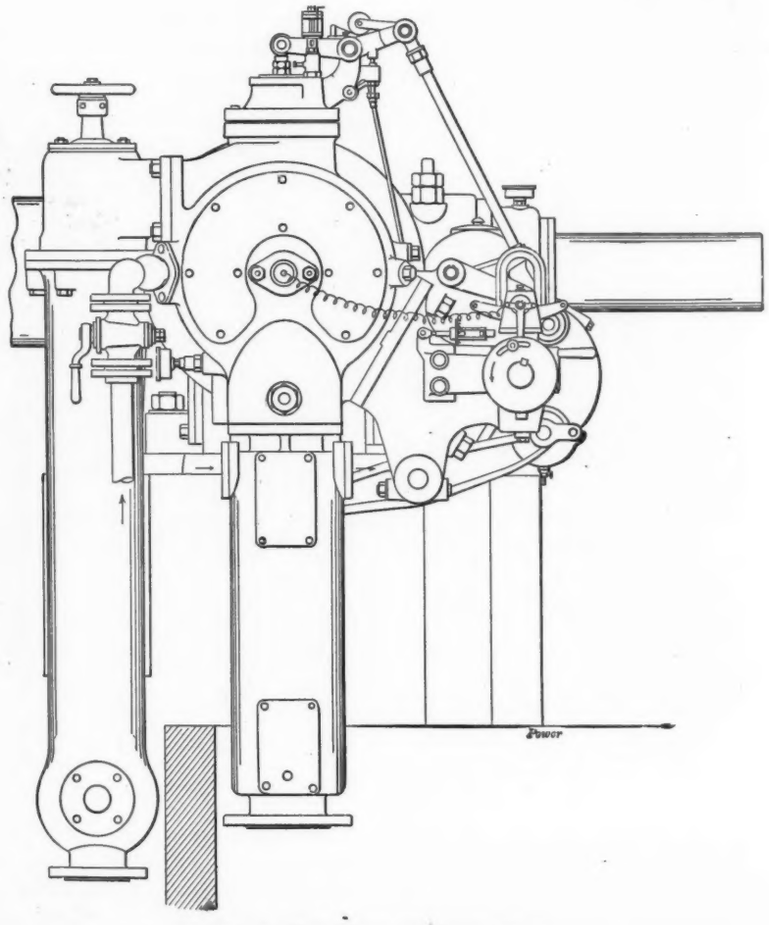


FIG. 5. END VIEW OF VALVE GEAR

Electrical Department

Parallel Operation of Direct Current Generators

By C. L. Greer

Especially conducted to be of interest and service to the men in charge of the electrical equipment.

In many power stations, especially those of the smaller sizes, whenever a new generator is needed it is frequently installed by the operating force. If the machines are direct-current and are to operate in parallel, certain conditions must be fulfilled to insure satisfactory operation and for cases like that mentioned the following may be of interest to those in charge of the work.

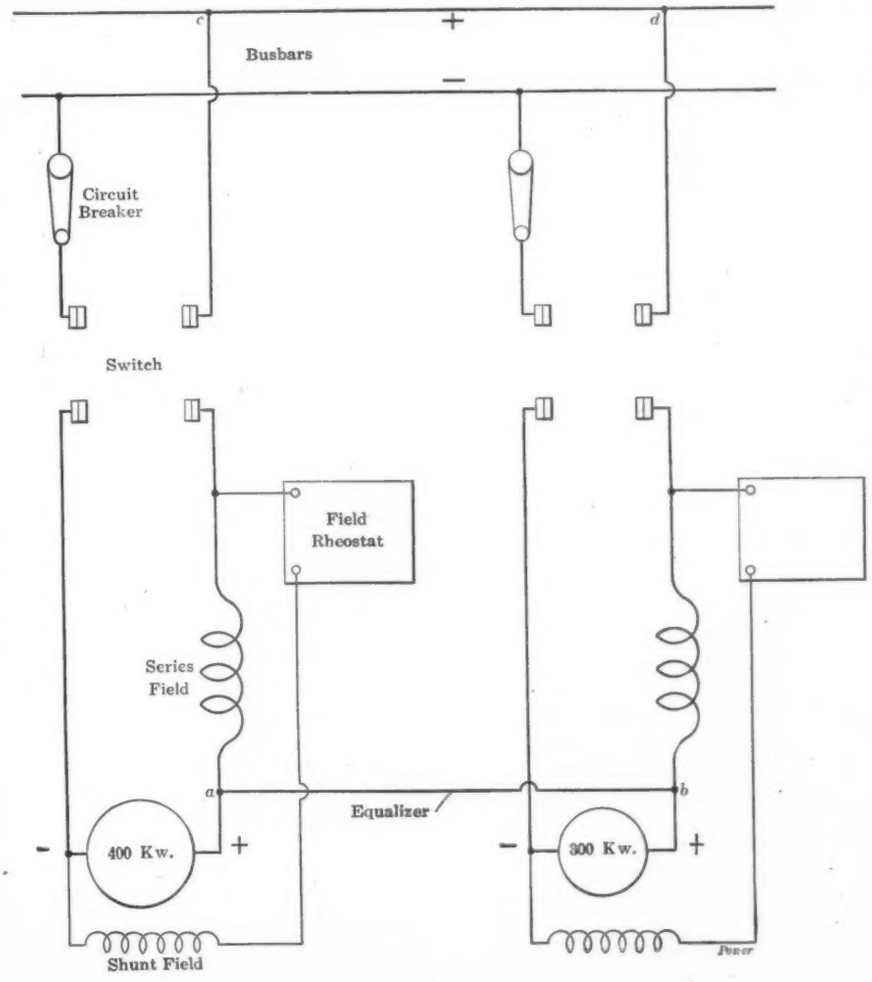
When direct-current machines of the same capacity and characteristics operate in parallel there is usually no difficulty experienced in getting a proper division of the load between them, but when machines of different capacities are to operate together the question of proper load division assumes a different aspect.

With a steady load and constant attendance the matter is not of so much importance as the proper division of the load may be accomplished by the adjustment of the field rheostat, but with a varying load such as that of a street-railway system, to give satisfactory operation each machine must automatically take its share of the load.

The first requisite for satisfactory parallel operation of direct-current machines is that they have the same characteristics. They must both have the same degree of compounding for any percentage of their rated load. If they do not compound alike, it is better not to attempt to operate them together unless the compounding can be made the same in both, which may sometimes be done by putting a dead resistance in the series field circuit of one machine; the material used for this resistance, or resistor, must have carrying capacity enough to pass the full-load current of the machine. If it is contemplated to operate machines of different types in parallel, however, it is well to consult with the makers regarding the changing of their characteristics.

Aside from the first requirement mentioned, there is another which must be met if satisfactory operation is to be obtained. This can be more easily explained with the aid of the accompanying diagram, which shows the connections of two generators intended for parallel operation. It is assumed that the two machines have the same degree of compounding and are alike in every way except in capacity. When the machines are carrying current there will be a certain drop in electromotive force between the positive brush of each machine and the positive busbar, this drop being due to the resistance of the field winding and the cable. Now to get a proper division of the load between the machines it is necessary that the drop from *a* to *c* in the one machine and its lead must equal the drop from *b* to *d* in the other when both are carrying their rated loads. To fulfil this requirement it is necessary for the series winding and lead of the smaller machine to be of higher resistance than that of the larger. If the distance between the two points is the same for both machines, then it is evident that the lead or the series field conductor (or both, perhaps) of the smaller machine must be smaller than that of the other. The operator cannot control or alter the size of the field conductor, so that need not be considered.

When conditions are normal there will be no difference in potential between the points *a* and *b* and therefore no tendency for current to flow between them. The conditions are practically the same as if one armature were delivering current to the two paths *a c* and *b d;* the current will divide between the two paths in proportion to their conductivity, which, if properly proportioned, will be such that only the current of one machine will flow from *a* to *c* and *b* to *d* respectively. But suppose that the conductivity of the leads is so proportioned that that of the smaller machine is greater than it should be with respect to the other. Then the current will not flow through the two leads in proportion to the capacity of the individual



Generators of Different Outputs Connected in Parallel

machines but a portion of the current of the larger machine will flow through the equalizer connection to *b* and out through the series field winding to *d*, strengthening the field of the smaller machine and thereby causing it to take an increased portion of the load. The way to correct this is to increase the resistance of the lead of the smaller machine enough to reduce the current to normal.

When machines do not properly divide the load the effort is sometimes made to make them do so by changing the field shunts or adding shunts if none are in use. This will not have the desired effect because when the two machines are in parallel the shunts are also in parallel and while changing the shunts will change the compounding of the machines as a whole it will have no influence on the division of the load.

To indicate how the principle under discussion may be applied in any case, it is perhaps best to assume a case and figure it through. Suppose that the 400-kilowatt machine represented in the diagram be already in operation and that it is desired to install the one of 300 kilowatts and make sure that each will take its share of the load when operating in parallel. It is assumed that the machines are alike except in capacity and that the resistances of the series field windings are such that when carrying full load the drops across the windings themselves will be the same. Suppose that the large machine requires 30 feet of cable to connect it to the positive busbar and that 50 feet of cable are required for the one of smaller capacity. Assuming a pressure of 650 volts the current of the large machine will be

$$I = \frac{W}{E} = \frac{400{,}000}{650} = 615$$

amperes and that of the smaller will be

$$\frac{300{,}000}{650} = 462$$

amperes. For illustration, suppose a cable of 600,000 circular mils to be used for the large machine (in practice it would likely be larger); then the problem is to determine the size of the cable for the smaller machine to give satisfactory load division. The drop from the 400-kilowatt machine to the switchboard, in the positive lead, will be 0.35 volt, and it is necessary, therefore, to make the positive lead of the 300-kilowatt machine of such resistance that the full-load drop in that will be 0.35 volt. This may be done by making the fraction

$$\frac{amperes \times distance}{circular\ mils}$$

equal in both cases. For the larger machine the equivalent of this fraction is

$$\frac{615 \times 30}{600{,}000} = 0.03075$$

For the smaller machine, then,

$$\frac{amperes \times distance}{circular\ mils}$$

must equal 0.03075; consequently,

$$\frac{amperes \times distance}{0.03075}$$

must equal the circular mils of the cable to be used, which figures out thus:

$$\frac{462 \times 50}{0.03075} = 751{,}220$$

circular mils; the nearest commercial size is 750,000 circular mils. This is larger than the cable of the 400-kilowatt machine, and the reason for it is that the length of the cable on the smaller machine is 60 per cent. greater than that of the larger machine. If it is undesirable to put in so large a cable for the smaller machine, a resistance bank of some kind could be inserted in the lead of the large machine to properly proportion the resistances of the two circuits. The effect would be the same but the inserted resistance should have ample current-carrying capacity to prevent excessive heating.

No matter what size cables are used the resistances of the two connections must be so proportioned that the drop will be the same for both machines between the equalizer junction and the main busbar when each is delivering its full-load current.

This rule holds good for machines of the same capacity, and where there is an appreciable difference in distances between the machines and switchboard the cables should be cut the same length and that of the nearest machine coiled or made up in some way to keep it out of the way.

In the example given it was assumed that the series field windings were on the positive side of the machines; if they were on the negative side the rule would then apply to the negative cable.

LETTERS

The Balancing Coil of a Three Wire Generator

Mr. Kerr's letter* on the subject of the three-wire generator contains one important error. He says, "as the coil is an autotransformer with a one-to-one ratio, it would have to be but one-half the size of a transformer of the same volt-ampere capacity" (true), "or 9 per cent. of the capacity of the generator" (wrong). He has already figured the capacity of the coil correctly at 18 per cent. of the generator capacity. The fact that the coil is half the size of a transformer of equal capacity does not reduce the size of the coil; it means that a transformer to do the same work would be twice as large, or equal in size to an autotransformer having 36 per cent. of the generator capacity.

This error does not occur in the next paragraph, which is inconsistent with the statement quoted. With an allowance of 25 per cent. unbalancing, as it is commonly termed, the neutral current being one-fourth that in the heavier loaded main conductor, each balancing coil, when two are used, must have a volt-ampere capacity of practically 4½ per cent. of that of the generator, and it would be the same size as a transformer of 2¼ per cent. of the generator capacity.

GEO. W. MALCOLM.

Brooklyn, N. Y.

*Page 1688, September 20 issue.

Polarity Indicators

R. T. White, in the August 16 issue of POWER, mentions a simple method of determining the polarity of two direct-current conductors. His method, though very good, necessitates the use of three articles: first, conducting wires; second, water, and third, a container for the water.

Were Mr. White to take a potato, one of the common or garden variety, and insert his two wires into a freshly cut surface, he would notice the region around one of the wires become green, due to the copper dissolved off the wire; this wire, surrounded by the green stain, is the positive wire. If both wires become surrounded by dark colored stains, the current is alternating.

Another method of differentiating between alternating and direct current, recently advanced in an Eastern paper, is to hold a bar magnet near a lighted incandescent lamp; if the "juice" is alternating, the filament will vibrate, if direct, the filament will be attracted or repelled, according to the sign of the magnet pole presented.

Mr. White is mistaken when he states that air bubbles form around the negative wire; the bubbles are of hydrogen gas.

WESLEY MCARDELL.

Brooklyn, N. Y.

When a boiler is to be cleaned, allow the fire to die out, and leave the dampers open with the fire doors closed for at least twelve hours, when the steam gage should indicate no pressure. Then admit air on top, open the blowoff cock, and allow the water to run out. Remove the upper manhole plate, and use vigorously a large hose with ample water pressure to dislodge loose scale, and wash out the boiler thoroughly. Now remove the lower manhole plate and all the handhole plates, and entering the boiler, remove the lodged scale at the turn of the flanges and below and between the tubes. See that all parts of the boiler are entirely free of scale and clean internally and externally from head to head, and see that the furnace is cleaned out from end to end. Examine carefully all parts of the boiler for defects, particularly the parts that are subjected to the direct heat of the furnace.

Readers with Something to Say

Condenser Trouble

The condensing outfit of a certain plant, when first installed, maintained an average of about 26 inches of vacuum. The plant was run from Monday morning to Saturday night. After it had been in service a few months it was noticed that when starting on a Monday morning the vacuum was about 25 or 25.5 inches, but toward the latter part of the week the vacuum dropped to about 23 inches. Later on, the vacuum was found to be about 23 inches when starting on Monday morning and as low as 18.6 inches by Saturday.

All of the connections were examined and found to be tight and free from leaks. The condenser was opened and it was found that the tubes were clogged. They were bored out, this operation being repeated each week, with the only result that the vacuum would be up to 23 inches at the beginning of the week. It would drop to 19 inches again by the end of the week. It was evident from this that something other than clogged tubes was causing the trouble.

The condenser manufacturers were appealed to and a representative was sent to examine the outfit. The exhaust from the turbine contained a quantity of oil. It was found that this had accumulated on the outside of the tubes. The circulating water, taken from a nearby pond, entered at 60 degrees Fahrenheit and was not very warm when discharged. The following Sunday, when the plant was shut down, the valves of the air pump and the piston packing were removed and the condenser was flooded with a solution of boiling water, saturated with soda; this removed all of the oily sediment. After being thoroughly dried, the condenser was shut off from the turbine, the circulating-water inlet and outlet were disconnected, a blank flanged placed on both openings and a 50 per cent. solution of hydrochloric acid was pumped through the condenser. This solution thoroughly cleaned the surfaces of the tubes. After being washed free from the acid, the machine was carefully drained and again connected to the turbine and the circulating-water piping.

When the outfit was started the following morning the condenser produced 26 inches of vacuum. After two months' running the vacuum began to drop gradually. When it reached 23 inches the same operations had to be repeated.

The cause of the trouble was easily traced to the circulating water, which caused scale to form in the tubes, and the oil in the exhaust steam, which caused the sediment to form on the outside of the tubes.

NATHAN OWITZ.

New York City, N. Y.

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words, wanted.

Continuous-feed Oil Reservoir

In a plant of which I had charge, there were 12 sight-feed lubricators, which were used for supplying cylinder oil to various pumps and engines. As it required considerable time to fill these lubricators, we decided to install an oil reservoir and to supply cylinder oil to each lubricator continuously through suitable pipe connections between the main oil reservoir and the several lubricators. Fig. 1 shows how the main reservoir was connected. As three of the lubricators were about 200 feet away from the reservoir, great difficulty was experienced in getting these lubricators to feed, especially in cold weather. Changing the steam connection to the oil reservoir as shown in Fig. 2, overcame the trouble entirely, and these far-away lubricators feed nicely. The steam connection was run to the highest point in the engine room which was about 34 feet above the reservoir. The drop pipe filled with condensed steam and thus furnished a hydrostatic head equivalent to about 15 pounds. As the steam pressure was 100 pounds, there was 115 pounds total pressure on all of the oil lines and lubricators. The 15 pounds excess pressure was sufficient to overcome the friction in the lines and to insure a steady positive feed.

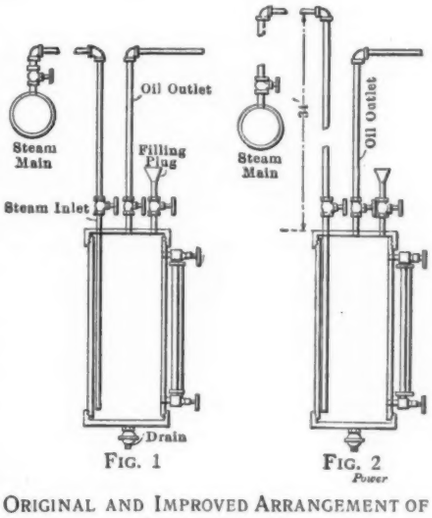


FIG. 1 FIG. 2

ORIGINAL AND IMPROVED ARRANGEMENT OF STEAM PIPING

PAUL MCINTIRE.

El Reno, Okla.

Why the Pump Made Only Two Strokes

The pump had been repaired in the early spring, then brought to the mine and tried out at the surface by connecting with the steam hose, and had run all right. It was then moved a few feet to one side and allowed to stand the rest of the season. The pump did not set level, however, but stood at quite an angle, and the cast-iron air chamber had been removed; a tarpaulin had been thrown over the rocker arms and piston rods, but the rest of the pump was exposed to the elements.

In the early part of November the pump was lowered into the mine, the old pump being disconnected, and the pipes connected to the new one. When steam was admitted the pump made only one stroke on each side and then refused to budge. The operating force worked with this pump from about 6 a.m. until 4 p.m. The water was then almost knee deep, or halfway up on the cylinders. At this point I was sent for in the hope that I might be able to start the pump; most of the tools, however, were under water. Something had to be done to prevent the mine from being flooded. Of course, the water did not raise as much at this time as when it first came up, as the area for the water to spread over was larger.

One rocker arm was disconnected and turned upside down, a new keyway was made, the key fitted, and a man operated the rocker arm, thereby working one side of the pump, the valve being disconnected and placed central over the ports. In about twelve hours the water was well down in the sump. The cylinder head was then taken off and the steam end and piston were found to be intact; the valve was found free and the ports were unobstructed; the packing from the rod was removed and everything found all right. A bar and sledge were applied to the spool on the rod, and the rod could not be budged. The cylinder cover of the water end was removed, and a block of hardwood applied there with a sledge, but still the plunger would not move. A jackscrew was then brought into play on the water piston and the pump was

braced across the gangway; by using the bar and the sledge on the spool and bearing on the jackscrew at the same time, the piston was finally moved. The side plates were then taken off and the solid plunger was sandpapered and oiled, and it was then found to be perfectly free.

The trouble was caused by water getting into the valve chamber, over which the air chamber should have been, and carrying with it more or less dirty sand, fine ashes and other material that is around a coal mine; this had dropped onto the solid plunger and was forced back into the casing, wedging the plunger fast. When these things were removed the pump ran as good as it did when it first came back from the shop.

H. R. ROGERS.

Seattle, Wash.

Zinc in Boilers

Our plant is equipped with two 5x16-foot return-tubular boilers, one of which is about ten years old, and the other about four. The operation of the plant is such that it is necessary to use only one boiler at a time; this is usually the newer one, the older one being used while the other is being washed; or, sometimes in very cold weather, it is necessary to use both boilers.

Soon after taking charge of the plant, I found upon examination of the new boiler that it was badly scaled for one in use so short a time—at that time only about a year. Upon making inquiry as to what was used to prevent scale, I was informed that a peck of potatoes had been used every time the boiler was washed out. As the boiler was washed every two weeks, it was evident that the potatoes were not doing their work. Having read that zinc is used in marine boilers with good results, and having used commercial mixtures, both dry and fluid, in other boilers without good results, I decided to give the zinc a trial. I bought seven pounds of zinc, drilled two holes through it, ran a wire through one of the holes and suspended the zinc from one of the lower tubes. I soon discovered that this was not the proper way to use the zinc as it soon crumbled and fell to the shell of the boiler. I accordingly made a basket of heavy wire screen, suspended it from one of the lower tubes and placed the zinc in it.

It was six weeks before I noted any results, then I removed nearly one-half a bushel of scale, and each two weeks thereafter for two or three months, I removed more or less loose scale. At present the boiler is free from scale. The purer and closer grained the zinc is, the better. I then tried the zinc on the old boiler, which was badly scaled, and again had good results. Shortly after this the boilers were inspected and pronounced to be in first-class condition.

Our heater is of the open type, and formerly it was necessary to remove the pans and clean them every four weeks. Since placing zinc inside them it has been necessary to clean them only once—a period of nearly eighteen months.

D. A. DICKINSON.

Lima, O.

Firing with Gas

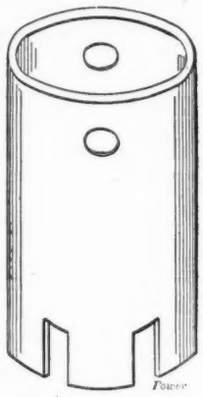
I would like to hear from some of the readers of POWER as to their experiences in firing with gas—how they arranged the checker work, draft and what kinds of burners gave the best results. I have tried several types of burners, but they all seem to allow most of the gas to pass up the stack only partially burned, as is indicated by clouds of black smoke.

F. P. WILSON.

Grafton, W. Va.

Homemade Tools

Having occasion to take valve seats out of the water end of our air pump, I made a wrench out of a piece of pipe by cutting notches in the end of the pipe to fit over the spokes of the valve seat. The seats are 5 inches in diameter and a piece of 4-inch pipe fitted nicely inside the outer ring of the seats. The figure shows how the wrench looks. By using



WRENCH FOR REMOVING VALVE SEATS

a rod in the hole at the upper end of the pipe or a chain tongs, the seats can be taken out easily with a wrench of this description. In making the wrench, care must be taken to cut the slots so that each will bear on a spoke when in use. I made the slots with a hacksaw and chipped out the pieces with a chisel. It took 15 minutes to do the job.

Another handy little homemade tool can be made as follows: If a wrench for hexagonal nuts is wanted, select from the scrap pile a piece of pipe which will just fit over a nut of the required size. Heat the end of the pipe, place it over a nut and pound the pipe down about it. A rod through a hole in the other end of the pipe or a pipe wrench completes a good homemade box wrench. One of these has saved the day for me many a time. They can be used in a hundred and one different ways about a plant.

I. VIGGERS.

Everett, Wash.

Bushing Valve Stems

Four valve stems and valve-port covers on a 75-horsepower engine were badly worn, and we undertook to bush them. The stems were 1¼ inches in diameter. We obtained some 1¼x1-inch cold-rolled seamless tubing, and turned down the long ends of the valve stems, that project through the bonnets, so as to make a tight fit into the 1-inch tubing. We cut the tubing the right length and forced it onto the stems, then recut ¼-inch key seats in the stems for the bell cranks; this gave a ⅛-inch key seat in the bronze part of the stems.

The pivot ends of the valve stems were so short that we decided there would not be bearing enough to force the tubing on them as we did on the long ends. Therefore, we turned them just enough to make them round; this made them 1 1/16 inches in diameter.

The covers were then bushed to fit the stems. In bushing the covers we turned off the rings which hold them in position, and bored a 1½-inch hole in each of them. Next, we turned some cast-iron bushings to fit the covers, each having a 4x⅛-inch flange on one end and a 1/16-inch hole. This flange was to take the place of the rings which were turned off the cover. We forced these bushings into the covers, and put two pins through the flanges into the covers to make sure they would not work loose.

These bushings and sheaves have been in service for two years and have not shown the slightest wear, and we have packed the glands in the bonnets only once. It is certain that these steel bushings will outwear a set of bronze stems, and they cost only a quarter as much.

E. W. NEAL.

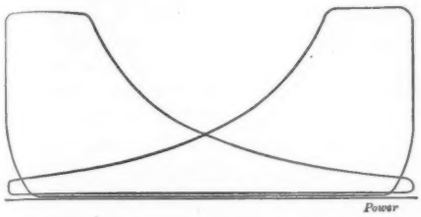
Pittsfield, W. Va.

Economy in Small Matters

While reading over the various items in several of the mechanical papers recently, my mind became centered on the question of high pressure in steam boilers and engines and the consequent results. High-pressure steam is theoretically an economy, but to secure this economy high-pressure conditions are necessary. When a plant is operating at top-notch load, especially an electric station, it may be economy to run at top-notch pressure. But it is questionable if it is wisdom to run very light loads at this same top-notch pressure, owing to the fact that, although the demand for steam is small, the loss by radiation from the various steam lines is high. Consequently, the percentage of condensation is greater than when the boiler is putting forth its full capacity of steam. Wear and tear is much less with low pressures and the water in the boiler being at a lower temperature, is better able to absorb the heat of the furnace gases than when everything is crowded to the full limit. There-

fore, it seems to me that everything points to the economy of low pressures for light loads.

It is only by rigid care and attention to leakage and small details that high-pressure steam can be made to yield the economy, or any part of it, that theoretically it should yield. Engineers are sometimes apt to cry over the old-fashion machinery that they have to operate, as though they felt it to be impossible to secure good results from anything that is not right up to date. But they are entirely wrong in this matter. I have seen better results obtained with old-fashion engines and boilers and under old-fashion conditions than have been obtained in a good many cases with new uptodate equipment. These good results were obtained simply by the use of care and attention. There was no want of safety-valve tightness, and the firing, while done by hand, was done intelligently so as to keep the steam at the necessary pressure and not cause it to vary—up to the blowing-off point one minute and down to half the normal pressure the next. A varying steam pressure is far more wasteful than is generally realized. Steam pipes were well insulated and the valve bodies as well. If a condenser was part of the equipment, the vacuum was carefully maintained.



DIAGRAMS TAKEN FROM OLD ENGINE

Injecting pipes are, to a certain extent, porous and, consequently, if they are very long, they let in a lot of air. Painting the pipes with a good boiler paint will prevent this to a large extent. All possible air inlets, such as at flanges or valve stems, should be carefully watched. An engineer should not be satisfied so long as the vacuum is not up to the requisite amount. It is all very well to look for things new and modern, but before advocating them be perfectly satisfied that they are better under the same kind of conditions than the old. An old engine is not always necessarily wasteful. Of course, age presupposes worn-out valves, scored cylinders and rods, but these are not always the conditions that exist. The accompanying set of diagrams was obtained from an engine that was built in 1861 and has been continuously in use since that date. It is 16x36 inches in size and runs at 100 revolutions per minute.

No manufacturer having common sense, will use an old plant if he can afford a new and more economical one, and the best way for an engineer to enable him to do so is to keep a sharp lookout for all the small losses and details and get the best possible results out of the old machinery. This will not only prove the ability of the engineer to care for the old plant, but will also prove his ability to care for the new one when it can be afforded. In steam-engine economy it is often easy to cut down the amount of fuel used 25 per cent. or more by simply looking after the small items which appear to many engineers to be of small consequence but which amply repay the attention bestowed upon them.

CHARLES H. TAYLOR.

Bridgeport, Conn.

Binding Copies of Power

Having received the index to POWER a short time ago it occurred to me that it might be useful to some other readers to describe my method of binding the copies of POWER for future reference. The scheme is easily accomplished and is inexpensive.

First, assort the copies so that they will be in successive order, the pages running from 1 to 1190, and comprising one volume for the first six months of the year. Then remove the covers; also the wire staples which hold the leaves together should be removed before the reading matter is separated from the advertising, otherwise the pages are liable to tear. Now, remove whatever glue that remains on the reading section and place the index at the front. Put some old sheets of paper on the outside of the outer pages so that the reading matter will not be soiled while the book is being finished; these sheets can be torn out later. Straighten the backs of the copies and lay them down on a bench or table, put a board on top of them and a weight on the board so that the paper will be pressed firmly together; if this is not done, large spaces are apt to remain between the individual copies. Now take a brush and some shellac or glue and put two or three coats on the back edge. When it is sufficiently dry, separate the book from the table and board by means of a knife, otherwise the book is liable to separate at the center on account of the shellac sticking to the board and table.

When this has been done procure a common nail four or five inches long and file it to a taper so that it can be pulled out easily after it has been driven into the paper. Drive five holes in the back margin of the book; then with a needle and a strong thread run it through all the holes, and tightly bind the leaves together. The book is now ready for the cover. For this I used a piece of insulating fiber paper, such as is used by electricians; this is about the same thickness as cardboard. After cutting a piece large enough for the cover measure the thickness of the book and, with the aid of a square, make two creases at the center of the cover. The fiber paper is rather stiff and hard to shape, consequently if the paper curls it may be made straight by moistening it with a piece of damp waste. Now, put a weight on it and leave it in this position for two or three hours; after which, again paint the back of the book with shellac, also between the creases on the cover, and put the latter on carefully, rubbing your fingers over the back of the cover where it is pasted so that the entire surface will stick to the cover. Repeat this for five or ten minutes or until the shellac is well set. The edges of the pages will be rough, but these can be trimmed by taking them to a printing office and putting them in the paper cutter. If fiber paper is not available, a sheet of tagboard can be used for the cover. This can be had at any printing office for 5 or 10 cents.

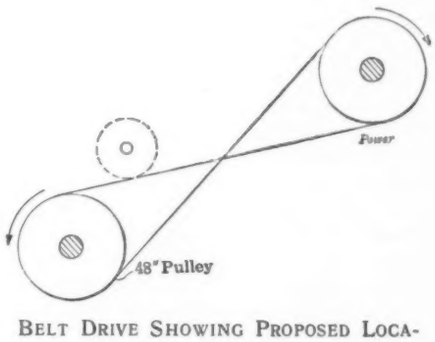
The binding of POWER did not cost me a cent outside of the time spent, as the material was picked up around the plant. I consider these bound volumes of great value as a reference library and would advise other readers to begin binding their copies at once as they are ten times more valuable when bound than when scattered all over the engine room. When indexed they are worth as much as a book costing $5, and yet they cost only $1 per volume.

LOUIS J. GORILLA.

Ironwood, Mich.

Trouble with the Belt

The accompanying sketch shows the arrangement of belt drive which has given us considerable trouble. The pulleys run at 400 revolutions per minute and are connected by an 8-inch, crossed belt, which continually runs off. Would an idler, placed as shown by the dotted lines, prevent the belt from running off, or would it cause too much friction at the cross? Also, would it be necessary to use a cone pulley for the idler, as the belt slants somewhat?



BELT DRIVE SHOWING PROPOSED LOCATION OF IDLER

I should appreciate opinions of POWER readers upon the foregoing.

RAY HAMILL.

Shelby, Mich.

Questions Before the House

Verdict on Canton Explosion

The verdict of the Canton coroner on the cause of the boiler explosion in that city is paralleled only by the one given by Mark Twain. Buck Fanshaw, suffering with delirium tremens, sent a bullet through his brain, cut his throat and leaped from a window three stories above the sidewalk. The coroner's jury, with their intelligence unblinded by the sad fate of their lamented friend, rendered a verdict of death by the visitation of God.

Seriously, however, is it not time for the public to have boiler explosions investigated by experts capable of fixing the cause instead of persons holding political office and absolutely without either the technical or practical training necessary to solve the question? In this case, essential facts, revealed by the testimony, were boldly ignored in order to assign a cause not warranted by the facts. The coroner knew nothing of boiler construction or operation. The mute testimony of the parts remaining could not pass through the veil of ignorance that surrounded the official who expects engineers to applaud his verdict. The fatuity of the man is appalling.

Perhaps, however, we may hope for a statement from the builders of the ill-fated piece of apparatus giving us their reasons for the construction that has resulted in such a disastrous explosion. Curiously, the boiler that exploded at Midvale, O., last winter was of the same construction. If these explosions were not due to structural design causing excessive flexure resulting finally in the explosion, what else was the cause? The water-hammer theory will not account for the explosion, for water hammer would rupture the plate directly on top.

In my opinion the time has arrived when boiler explosions should be investigated properly. Neither the maker, the owner, nor the attendants should be screened. This business of perfunctorily turning over such matters to minor officials having no knowledge of boilers is stale and rank. Nobody is punished and none censured unless he be killed in the affair. The matter is forgotten until recalled by the next explosion. Massachusetts, alone, of all the States has rules worthy of consideration, but it does not appear that the Buckeye State will even consider the adoption of similar rules until more explosions have occurred and more lives have been sacrificed.

The discussion of this and similar explosions in POWER should result in the various associations connected with steam engineering taking some positive stand in regard to demanding the adoption of the Massachusetts rules in the several States and having the governors appoint men of ability to investigate explosions in the future.

A. J. FORAN.

Paterson, N. J.

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues.

Flue Gas Analysis and Calculations

An error appeared in the article on "Flue Gas Analysis and Calculation" which was published in the August 9 issue. In the small table at the foot of the first column on page 1416, the molecular weight of nitrogen was given thus:

$$N = 14.$$

Correctly, this should have been,

$$N_2 = 28,$$

for a molecule of any gas is considered to be composed of two atoms. As the atomic weight of nitrogen is 14, the molecular weight is, of course, 28.

This necessitates a revision of the calculations at the foot of the second column. The weight of N, instead of being

$$80 \times 14 = 1120,$$

is

$$80 \times 28 = 2240.$$

Then the total weight, instead of being $28 + 440 + 228 + 1120 = 1816$ weights, is $28 + 440 + 288 + 2240 = 2996$ weights. The part by weight for CO is, therefore,

$$28 \div 2996;$$

that of the CO_2 is

$$440 \div 2996,$$

etc., and *not*

$$28 \div 1876$$

and

$$440 \div 1876,$$

as was given. The last sentence in the third column on page 1416 must be changed to read: In the case cited the oxygen used to make the mixture is

$$624 \div 2996$$

of the whole.

The table on page 1417 headed "Convenient Form for Flue Gas Calculations" must be corrected for the nitrogen (N) weight in the last column to 2240 and the total weight to 2996.

The errors in no wise affect the accuracy of the actual calculations of results, for the erroneous figures were not used in obtaining the results but simply included to lead up to the principle of the method employed.

F. R. GRADY.

New York City.

Engineers' Wages

My experience covers several stages of machine-shop work, construction work, general engineering and finally operating work in which I have now been engaged for the past seven years.

Being wholly a practical man, educated by night study, employed principally by large concerns, I have met with all classes of engineers—technical graduates and practical men—and have made a careful study of them all.

Rarely is the technical graduate found as an operating engineer for he almost invariably turns to office work, construction work or to the sales department of some concern. This, then, leaves the operating work almost wholly to practical men.

Why have not the operators improved their positions?

My answer is that the practical man, as a rule, has been busy training himself not so much to carry the larger responsibilities which come with an advanced position but training himself and his hands to do skilled work with and on the operating units where his work calls him. Admiration is often expressed of the skilful work of one of these men, but how often the one that gives him the highest praise is compelled to say the fatal words that bind him forever to this work with no chance to advance.

These are the words, "A better man cannot be found as long as he is not given more than he himself can do. For if he is given charge of men he fails absolutely in the management of them."

Many a time have I heard this verdict passed; it is not uncommon to hear the same of technical men even after they have had several years of practical experience. Successful supervision of others is a gift, but training can go a long way toward assisting one to whom it does not come naturally. In this the technical man has an advantage hard to overcome for the training he has received has caused him to see the advantage of it.

The operating engineer must start at

the bottom and slowly work up. This takes several years and usually is more or less of a grind, for he must depend on those over him to advance him and instruct him.

This, to my mind, brings us, in the end, an engineer slow to take the initiative, slow to push himself forward and deficient in confidence in himself to handle things alone except on work with which he is perfectly familiar.

As to salaries, they are not what they should be but a gradual change is going on and with improved working hours, under better conditions, a different class of men is entering the field and gradually replacing those who are not so competent. With the license laws now in and going into effect, we must expect to get a better educated, better trained and better class of men all around in this field; men who by attaining better results will command better salaries.

WILLIAM WELSH.

St. Joseph, Mo.

I have read POWER for some years merely as a matter of self-education. My duties are not such that I may be termed in any sense an "engineer," nor my qualifications such that I could assume that title; yet I enjoy absorbing the information and endeavoring to solve the problems found in the columns of POWER fully as well as though stationary engineering were my chosen profession or means of livelihood.

On any of the technical discussions I do not feel competent to speak, as I realize that what knowledge I have acquired is strictly elementary by comparison with that possessed by a vast majority of POWER readers. There is one topic, however, dealing with the business side of the profession on which I feel that I have the privilege of speaking for the reason that I am a disinterested party, yet one who has had the opportunity to make some little observation of the relation between an engineer's efficiency and his wage rate.

I have read that there are "good, practical, operating engineers bearing responsibility equal to or greater than that of foremen, superintendents, etc., yet receiving as their remuneration little more than the wages of unskilled labor," or words to that effect. Now, if this is true in any case, I have no suggestions to offer other than that it possibly is a matter which should be referred to the physicians and judge of that section of the woods who determine who of the population may be the guests of a certain well governed hotel maintained by each of the States, for there are ways too numerous to mention by which a man who really possesses qualifications can readily find a market for his services. If he endures the outrage of being underpaid, he thereby casts reflection on the truth of his claim to more than the "unskilled-labor" degree of intelligence.

I believe that a little story of my own personal experience will illustrate best what I wish to say on this subject and call attention to the causes operating to keep some engineers plodding along in the poor-pay rut other than the injustice of society in general, "Providence," or whatever cannot be blamed on their ancestors or the Republican party.

I once had a friend who was an "engineer"; he had proved it by drawing pay as one for some twenty years, and by never blowing up a boiler, nor completely forgetting the use of his oil can. He was steady, sober and reliable, always put in full time and never caused a shutdown. For these reasons he considered himself underpaid at $3.50 per day. He spent considerable time telling about this to anyone who would listen, and gradually he got into the habit of being dissatisfied with everything and everybody, until he earned the title from the other employees of the establishment of "Sore head"—this was paid promptly.

As time rolled on, the old engine and boilers wore out and were replaced by new ones of higher rating. To the surprise of all concerned the new equipment failed to develop the power which was expected of it. An investigation followed.

It was evident to the nontechnical parties interested that the space under the boiler was sufficient to burn the required amount of fuel; by comparison with similar installations it was evident that there was sufficient heating surface; rapid combustion led to the belief that there was draft enough; the lines of the engine were evidently properly proportioned, and the engine itself bore no indications of inefficiency. Yet, when the boiler was crowded to its capacity as soon as the load went on, the gage hand would drop to one-half of the pressure at which it should stand even when the load was known to be only a fraction of the boiler's rated normal capacity.

The "engineer" was called upon to explain. He said that he guessed they would have to run a boiler trial and analyze the flue gas and indicate the engine; but all of these things were the work of an "expert" and he could not be expected to know anything about them.

The folks about the place noticed that the exhaust was more like the noise of a skyrocket than that of a roman candle, but they were not engineers and that circumstance relates to what the firm paid an "expert"—something like $25 per day to investigate for them. This "expert," who really was one, told us that his learning was entirely self-acquired and obtained at night. It made him worth, some months, about one or two hundred dollars in addition to his regular salary without interfering with his regular duties.

Referring again to our disgruntled friend:

I have very vivid unpleasant recollections of once trying to interest him in a correspondence course similar to one I was pursuing as a pleasure. I do not believe it necessary to add any words of explanation; those to whom they are necessary would not heed them any more than our friend did. But it might be well for anyone disposed to believe some of the "hard-luck" tales that are told to investigate and determine for himself if interested. A thorough diagnosis of a case would disclose whether the party so downtrodden is fit to bear the title "engineer" or whether he is merely a "stopper and starter," an "oiler and wiper," or a "whistle blower." I believe that we all will agree that some power-plant equipment is intrusted to "unskilled labor" and that the "unskilled" ones get paid all that they are worth until they begin to think, when they will at once become of more value to their employers.

Now, as for the comparison with foremen, superintendents, etc., if these men all were interviewed there would, no doubt, be quite a few of them who would report that they were overworked and underpaid. But, like the breakfast food, in most cases an investigation would reveal that "There's a reason." If a foreman were called upon for an account of his department and replied "get an expert" the management, I believe, usually would—it would probably be necessary.

It would then probably get a *foreman*.

W. R. SMITH.

Alton, Ill.

Pumping Layout

In his inquiry in the August 9 issue, Mr. Fillmen does not give the hight of the suction lift or the probable distance the water would be lowered when 75 gallons per minute were being taken from each well. If the water remains within good suction distance and does not carry too much air or gas, there will be no difficulty in handling the three wells with one pump, providing the suction lines are properly connected and suitable arrangements are made for priming the pump. However, if the water goes below easy sucking distance, an air lift will be more satisfactory. To ascertain the approximate quantity of air that will be required, it is also necessary to know the amount the water will lower or the total lift above the water level in the well. The discharge pipe from the wells carrying the air and water should be run vertically to the full hight and equipped with separating tanks at the top, as horizontal or inclined pipes are not satisfactory in an air-lift system, the air tending to slide along on top of the water and thus reduce the efficiency materially.

If the total lift does not exceed 80 feet and a submergence of 160 feet or

a ratio of 2 to 1 is used, with the proper arrangement of piping, the amount of free air used will be approximately 0.55 cubic foot per gallon of water. The air pressure required will be 72 pounds. If the total lift is 100 feet and a submergence of 200 feet can be obtained, approximately 0.65 cubic foot of free air will be required for each gallon of water pumped. About 90 pounds air pressure will be needed in this case. The above is based on the actual amount of air delivered at the well, and makes no allowance for any deficiency in the volumetric efficiency of the compressor. The air lifts can be operated with considerable less submergence. In that case, more air and less pressure will be required.

G. A. REICHARD.

Los Angeles, Cal.

Operating Mechanical Tube Cleaners

I read with interest the letter by Mr. Guèrin in the August 9 issue of POWER in which he tells of some of the troubles he has had with boiler-tube cleaners and unskilled labor.

I agree with him that the operation of removing scale from boiler tubes should not be entrusted to ash shovelers or any other cheap help about the plant as most tube cleaners need careful handling if all of the scale is to be removed without injuring the tubes. However, the cleaner that I am now using could not make as much trouble as the one Mr. Guèrin used.

My tube cleaner employs the revolving-head principle, that is, there are a number of cutter wheels revolving on a spindle and bearing out against the tube walls under the action of centrifugal force. By repeated tests I have found that it is impossible to injure the tube if this cleaner is allowed to run in one spot for some time as evidently the centrifugal force developed is not powerful enough to cause the cutter wheels to remove any of the metal or to spread the tube. In fact, no serious spreading of the tube could occur as the swing of the arms is limited, that is, they can only bear out to a diameter very slightly larger than that of the tube.

FRANK J. MCMAHON.

New York City.

Boiler Inspection

The editorial in a recent issue of POWER on boiler inspection is right to the point and I will venture to say that there is not an engineer reader of this paper who, at some time, has not seen boilers inspected in the loose, don't-care manner described. It is of vast importance to the engineer as well as to the owner that a thorough inspection be made by a competent inspector. There are a great many engineers who are not thoroughly posted and do not thoroughly understand this class of work, because they have only had the opportunity to examine a few boilers. The inspector, however, is at it every day, and practice makes him perfect.

I believe that all boilers should be inspected by a Government inspector with the assistance of the engineer or fireman in charge of the boiler regardless of the insurance inspectors and at regular intervals, say, at least twice a year. Also, that all engineers or firemen in charge of boilers be compelled to pass a satisfactory Government examination covering the individual classes of boilers under their charge. Further, that a heavy fine or imprisonment or both be the penalty to the manufacturer, owner and operator of any boiler that is found to be defective or that explodes. A committee of competent men who thoroughly understand this class of work should be employed by the Government to pass on all boilers that are found defective by the inspector or engineer and on all exploded or otherwise damaged boilers.

Change the inspector's job from a political one to a meritorious one either under the civil service or Department of Labor.

The above, in my belief, is the only way in which to stamp out incomplete inspections and incompetent inspectors. Naturally this will reduce the number of defective boilers in operation and thereby decrease the number of explosions and the accompanying loss of life and property.

J. CASE.

Hyattsville, Md.

Diagrams for Criticism

In the issue of August 16, J. D. Robertson asks for information concerning his indicator diagrams. I notice that the admission is rather late on the crank end. Further, I note that the cutoff is a trifle early at both ends. All other points appear to be all right; so, if these two defects are corrected, the running of the engine will be improved. No doubt the wavy lines noticeable on these diagrams are due to vibrations in the motion of the pencil when a sudden change in pressure occurs. These effects are generally shown by all high-speed engines. They show that the indicator piston is in good condition and is working easily.

C. TRUBE.

McKeesport, Penn.

In the August 16 POWER Mr. Robertson presents a set of diagrams for criticism. While they are far from being bad, certain points may be improved, notably the steam line up to the point of cutoff which at present is hard to locate. It is taken for granted that the steam pipe is of sufficient size and that the ports are ample. I would first advance the eccentric so as to give an earlier opening and cause the steam line to be more nearly horizontal to the point of cutoff. This will make a more definite cutoff and cause higher compression, which, at the present is equal to about two-thirds of the boiler pressure. If less compression is wanted, simply change the exhaust rods to suit.

I suppose that there is a definite reason for carrying the high back pressure which is indicated by the distance between the atmospheric line and the back-pressure line. The back pressure seems to be about one-eighth of the boiler pressure. If the latter is 150 pounds, this would mean about 19 pounds back pressure. I advise Mr. Robertson not to bother with the technical defects of the diagram but to seek every possible way of decreasing the excessive back pressure which has a coal-wasting influence.

A. C. WALDRON.

Revere, Mass.

Creeping Water Meter

The article by A. E. Holman in the August 16 issue of POWER, is of more than passing interest to me because of similar experiences that I have had.

In a factory where I was engaged in making some tests, it became necessary to shut off a ¾-inch disk type of meter for some three weeks. During this time it ran up a bill of about $30 for water passed. The proprietors of the factory very justly refused to pay. This caused a lot of trouble with the water board of the city. The meter was connected by valves on both inlet and delivery side. When it was shut off only the valve on the delivery side of the meter was closed so that the inlet side communicated directly with the supply pipe.

As I did not know anything of this trouble until after the tests on which I was engaged had been finished, there was no opportunity to attempt a solution of the queer action of the meter and it still sets me to guessing at times. While Mr. Holman's explanation may be the proper solution in his case, it does not fit the case I have just described for the delivery pipe beyond the valve had been disconnected, which was evidence that the valve did not leak.

In another case, a neighbor had a ½-inch disk meter in his house that jumped his quarterly water bills from about $6 up to $15 or more. I took one of my plunger meters and connected it beyond the disk meter so that no water could be drawn until it had passed both meters. My friend's bills dropped back to about $5 per quarter. Both meters registered practically the same, and for over 15 months they continued to do so.

My solution of this case is that when a tap was opened wide the water pressure, which is about 125 pounds, set the disk to spinning at such a rate that the momentum kept it going after the tap was closed, but when the plunger meter was

connected it acted as a brake and prevented the disk from attaining such a high velocity. In making the connections I had to use a number of tees in place of elbows; these also acted as a check to the flow of the water.

A third case fairly disgusted me with disk meters. I wanted to use a ½-inch meter in a great hurry and went to the superintendent of the city water works to rent a meter that I could carry along with me as I had no plunger meter that I could get to the job in time. The superintendent kindly let me have a new meter, one that had never been in service. The first thing that I did was to calibrate the meter. To my surprise, I got less than 43 pounds of water for each foot registered.

This experience made me skeptical about my house meter which had been in use some eight years. As soon as possible I made a test of the house meter and found it to be shy about nine pounds to the foot. I entered complaint at our water-board office, and a city expert (?) was sent to make an investigation. This he did by opening the tap in the kitchen sink and then looking at the meter which was apparently registering the flow. He went back to the office and reported the meter as being all right.

When I tried to get redress from the "thick necks" in the water-works office I was told there was no law in the country to compel me to use the water and that I could "take it or leave it," just as I pleased.

The foregoing is submitted to show why I have lost faith in disk meters, which were evidently placed on the market to supply a demand for something cheap, as well as to show that a "cheap" machine is no more reliable than a cheap mechanic.

W. H. ODELL.

Yonkers, N. Y.

In the issue of August 16, A. E. Holman describes the case of a creeping water meter which is of much interest to water-works people and of general interest to all of us.

We have a similar case where a water meter, attached to a main at the top of a rise, as shown in the cut on page 1477, registers about double the amount of water that seems actually to be consumed.

We have been totally at a loss to account for this condition as we had always believed that a water meter could not register *more* than the amount of water being consumed or leaking through. In our case there is no hot-water tank attached to the house fixtures as shown in Mr. Holman's cut; the hot water is gotten from an instantaneous water heater.

I would be very glad to hear from other water-works men who have had similar trouble or who can give information about water meters registering more than the correct amount consumed.

ROBERT L. RUDDELL.

Glenville, W. Va.

License Laws

I have read with interest for many years the printed discussions on engineers' license laws. So far, I cannot agree with the opinion generally expressed that the engineers should work to have laws enacted requiring them to pass an examination and secure a license before they are permitted to operate a steam plant.

The foremost reasons generally advanced by the advocates of license laws are, public safety and the making of more competent engineers.

If we are to take the foregoing reasons seriously, it would seem that the engineer is posing as a public benefactor in the first case and in the second case he is asking the public to insist on his being a better workman than he may be of more value to his employer. The inconsistency is obvious. If, being an engineer, the danger of having an incompetent man operate a steam plant is more apparent to him than it is to the public and, as a public-spirited citizen he sees and attempts to do his duty, then he is consistent as a public-spirited citizen. He is indeed a public-spirited citizen who will deliberately force upon himself a condition which compels him to apply himself vigorously many hours each night through a period of years to ground himself in a profession, the branches of which are ever growing wider and more intricate, and, after belaboring himself with work, worry and inconvenience, submits meekly, nervously to a scorching examination by the very men in whose hands he has deliberately placed the power to give or refuse superciliously the right to him to earn an honest living. I say that he is a generous soul to force this upon himself in the interests of the dear public with never a thought of self.

As for the second reason, that of making more competent engineers, that too shows a broad and generous spirit. It borders on the humorous when we ask the State to *compel* us to be that which we so earnestly desire to be. No doubt, it will be argued that it is the few ambitious ones that are advocating this in order to compel the laggards to apply themselves that they may become competent and proficient. But, I ask, *why* you are interested in the great body of laggards becoming competent and proficient? Your answer, coming from such a source, cannot be other than thoroughly unselfish, ennobling and inspiring. You would probably say that you wish to share with your fellow craftsman the beauties and pleasures which are enjoyed only by those whose mental faculties are developed to the highest degree.

I believe that it is not condescending to grant that the engineer is governed by the same impulses and motives as the rest of humanity. When we say that selfishness is a very pronounced characteristic of the human family and that the engineer has inherited his just share, I believe there is no exaggeration. The foregoing granted, it becomes necessary to expect from the engineer *some* human conduct. To be frank, I have been and am now of the opinion that this license agitation is a veiled, insidious move with no other end in view than to make scarce the supply of engineers that the scarcity may fructify to those remaining. I believe that the craft to a man thinks that a strict license law would increase the salaries of all and make conditions better and that this is the underlying motive for all this license agitation.

If we look at the engineer in those States which are strictly licensed we will find that his hours and wages are not any better than those in the no-license States.

I am sure we would all be interested in such data as it is possible to gather from examining boards and other sources, to find out whether the license laws have been of any real benefit to the craft. I think that they have not. On the contrary, I think that they have been an annoyance and an added worry.

In this city we have had an ordinance for the last five years which requires us to be licensed. In that time we have paid for renewals approximately $5000 and in return we have not received directly or indirectly five cents' worth.

Approximately 1 per cent. of the population of this city is employed as operating engineers. Assuming that this proportion holds throughout the country, it will be seen from the census, that the operating engineer, at an average of $1 per head, would be paying about $1,000,000 per year if we had a license law in every State. Why we should desire to contribute this fund and be pestered with examinations, is more than I can understand. The total amount of property destroyed probably would not equal in value the above named sum, and it would be unreasonable to expect accidents entirely to disappear in the licensed area. In fact, they are not eliminated in those States where the examinations are making the boys scream.

The engineer need not work himself into a frenzy for the safety of the public or for the protection of his employer's property, because it is plain that the public depends far more on the intelligence of the employer than on that of the engineer and the employer would be vexed if he knew that the engineer thought that he could injure his property without his permission.

J. J. NIGH.

New Haven, Conn.

Clearance and Compression

By V. Dwelshauvers-Dery

The author replies to Professor Heck's criticism of his article on compression, pointing out that that criticism was founded on the empirical indicator diagram for which isothermal compression and expansion of a perfect gas are assumed. In practice there is no perfect gas, isothermal compression and expansion are not realized, nor do actual compression and expansion follow the same law. These facts, the author argues, invalidate Professor Heck's argument.

In Professor Heck's article, on page 1657 of the issue of September 13, he seems to think that my experiments have merely opened the question of the economy of compressing steam in the clearance. This in itself would be a success not to be despised. But his theory has not only neither solved the question nor closed the discussion; it has not even opened up the question, since it was done already. Although well presented, this theory rests upon not a single practical fact nor a single experimental result, but upon nothing more than the "traditional theory" of the steam engine, which estimates the work performed at 20 and even nearly 40 per cent., and the consumption at about 100 or 200 per cent.

Indubitably, his remarks tend to cast doubt upon the general applicability of the conclusions derived from my experiments, but they do not even approach a discussion of them. To the facts that Nature offers he opposes hypotheses without experimental basis, and on this needle point he erects a monument, attractive perhaps, but which even a light breath may throw to the ground in a heap.

My engine, he says, is too small; the phenomena of heat exchanges between the wall and the steam are too pronounced; their laws differ from those observed in large engines. But when one wishes to study experimentally the laws of a phenomenon, is it wise to surround oneself with conditions that reduce it rather than with those that accentuate it? To assume that my engine was too small is to undertake a precise determination of the size at which the conclusions will begin to change or to be overturned. I calmly await this information; only it must be supported by experimental facts, and not merely by statements which one frames in his office—the only sort presented in Professor Heck's article. I shall render this evident, proceeding step by step and presenting again the diagrams accompanying that article.

Referring to Fig. 1, Professor Heck says: "In expansion, this steam is supposed to retrace the curve *G F E*, giving back the work that was expended in compressing it." This supposition is entirely gratuitous, since the *actual* law of expansion is not at all the same as that of compression. This fact is sufficiently demonstrated in POWER for June 28, 1910, on page 1164 and those following. If the law of expansion were the same as that of compression, there would be no room to discuss the economy of compression. Under that condition, *with complete expansion, complete compression would annul the detrimental effect of the clearance,** and incomplete compression or expansion could suppress only a part of it.

Professor Heck rests his entire argument upon the hypothesis that the expansion and compression of the steam act according to Boyle's law,

$$p v = \text{a constant},$$

a law which is applicable *only to a perfect gas and then only for an isothermal process.* But in steam engines, large or small, the temperature is constant neither during expansion nor during compression; and, moreover, the medium is a vapor which by no means resembles a perfect gas. In engines, large or small, there take place reëvaporations during expansion; and, during compression, the steam begins to become superheated until the instant when, having become hotter than the metal of the wall, it loses its superheat and begins to condense. These are *facts of experience* and not hypotheses; while the actual curves traced by an unconscious instrument, the indicator, are not equilateral hyperbolas.

Professor Heck says: "If the expansion curve is carried up to the initial pressure at *J*, the length *P J* shows the volume which the total steam in the cylinder would have at that pressure. Of this, *P G* is the clearance steam and *G J* is fresh working steam, so that *G J* is a measure of the steam received from the boiler." This statement is purely fanciful for several reasons, as follows:

First. During admission there has come from the boiler into the cylinder a certain weight of steam, a notable part of which

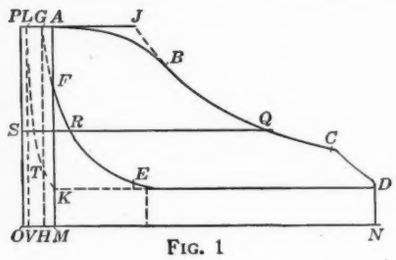


FIG. 1

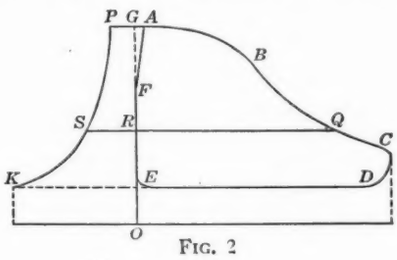


FIG. 2

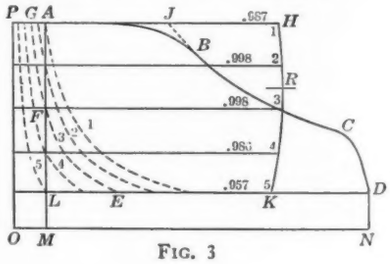


FIG. 3

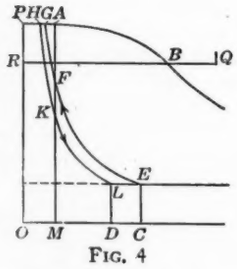


FIG. 4

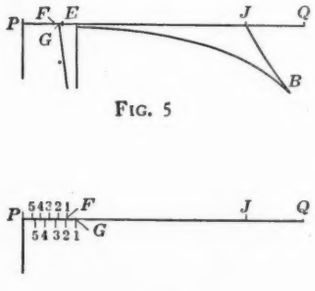


FIG. 5 FIG. 6

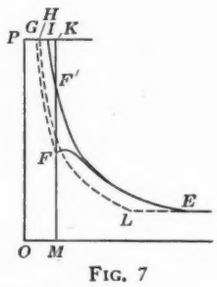


FIG. 7

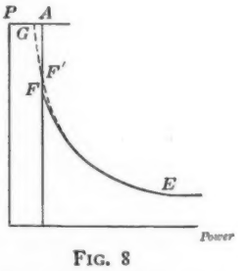


FIG. 8

*See page 1157, POWER, June 28.

is condensed, in order to compress the clearance steam, to reheat the metallic walls and to perform the work. The part condensed upon the walls, in large as well as small engines, is always considerable, so much so indeed that it has been given the special name of "missing quantity." It is reduced by various means which I shall not discuss here, such as jackets, superheating, etc. Without these it would amount to 20, 30 and sometimes even 50 per cent. of the weight of fluid coming from the boiler.

Second. The extension $B\,J$ of the curve is arbitrary; if we are dealing with a curve given by the indicator, it will differ from one diagram to another; if it is drawn according to a hyperbolic curve, it is certainly false. Nothing is able to locate mathematically the position of the point J. Yet it is upon this position that Professor Heck rests his entire method. A single practical means is at hand to determine accurately the weight of steam present in the cylinder and the weight of condensed water on the inclosing walls at the moment of cutoff. From the indicator diagram and other experimental data are determined with precision the volume v occupied by the steam at cutoff and its pressure p; the steam tables give, for this pressure, the weight δ of unit volume, and the weight of the volume v is $v\delta$. The product is the weight of pure steam present. If it were necessary to determine the volume that this weight would occupy at the pressure $O\,P$, equal to p', we should look in the tables for the weight δ' of unit volume at this pressure, and should calculate the volume v' by the equation

$$v\delta = v'\delta'$$

which obviously transposes to

$$v' = v\frac{\delta}{\delta'}$$

From this is derived the dimension $P\,J$ in Fig. 1.

There is needed more than 25 and even 50 per cent. in order that the weight of steam represented by $P\,J$ or $G\,J$ shall be the same as that which has passed from the boiler into the cylinder, even in large engines running at high speeds, but without jackets, etc. For clearness I shall designate by W this last actual weight, measured in an experiment. We determine it exactly by means of a surface condenser where the condensed steam which has acted in the cylinder remains separate from the condensing water, and may therefore be weighed on discharge from the air pump. The engine is caused to run regularly during a time sufficient for the purpose; the number of revolutions made in this time is counted, and the water coming from the air pump weighed. Simple division gives the weight of steam that has come from the boiler and acted in the cylinder *per* revolution of the engine. *If the two piston strokes during one revolution are absolutely alike,* with regard to the clearance space as well as the point of cutoff, the weight of steam *per piston stroke* (W) will be equal to half of the weight *per revolution.* If the two piston strokes are not rigorously alike in every particular, nothing certain can be derived from the experiment.

It is necessary, on the other hand, to determine as accurately as possible the weight w, of the clearance steam, which cannot be ascertained directly from the experiment. The indicator diagram, taken with all necessary care, of course, shows the pressure and volume of the steam at the beginning of compression; with good steam tables one can deduce therefrom the weight,

$$v_o\delta_o = w$$

of pure steam in the cylinder at this moment, if the steam is saturated or wet. The degree of dryness or moisture cannot be determined unless the temperature of the steam at the same time is determined experimentally by means of an instantaneous thermometer, such as that of Armand Duchesne. Hirn supposed, and George Duchesne has demonstrated* that we may without danger of appreciable error assume that the steam is dry or slightly superheated because it is surrounded by walls hotter than itself. The fact has been proved experimentally upon the small engine of the Liège laboratory by Mr. Duchesne. Moreover, it is not disputed by Professor Heck, who says: "It is proper to take the clearance steam as dry at E."

Now, by the means just described, we determine the total weight $W + w$ of fluid present in the cylinder at cutoff, as well as the weight $v\,\delta$, of pure steam. What is called *quality* of the steam is then

$$\frac{v\delta}{W + w}$$

and the "missing quantity" is

$$W + w - v\delta$$

It is far from this to the pencil marks $B\,J$ and $F\,G$ arbitrarily given on a scrap of paper. However attractive may be the easy theory of Professor Heck, it may be pronounced unreliable in practice.

Professor Heck's Figs. 2 and 3

All the curves of compression in Figs. 2 and 3 are traced according to the law $p\,v$ = a constant, which never followed in any engine, whether small or large. They are used to measure the work just as the position of the point J is used to measure the quantities of steam; they deserve no confidence whatever. The method by which the figure is traced conduces only to a fictitious explanation of the problem. The work called effective $A\,B\,C\,D\,E\,F\,A$, is not that which the indicator would give, but only that which the author of the diagram has imagined. It is the same with the volume $G\,J$ to which this work is related. And, even in these imaginary conditions, the curve $K\,R\,H$, Fig. 3, is still very slight; the maximum abscissa R differs little from the smallest, and even if this diagram were based on a solid foundation, the numerical conclusions derivable from it should be regarded with caution; the more so since no account is taken of the thermal action of the walls.

Fig. 4

Professor Heck says: "It is proper to take the clearance steam as dry at E; if compressed along the curve $p\,v$ = a constant, it will be slightly wet at G." So he thinks that we can compress the steam along the curve $p\,v$ = a constant. But we cannot compress it as we would like; we compress it according to the law which Nature imposes and which the indicator is suitable to show; and this law is never that of Boyle in steam engines. My experiments, like those of the brothers Duchesne, demonstrate positively that from the beginning of compression the steam becomes superheated more and more, both by the work expended upon it and by the heat from the hotter walls; this latter effect is, however, small, because of the gaseous condition of the fluid in contact. By this double action, the steam becomes hotter than the metal and yields some heat up to it if there is time, that is to say, if the compression is sufficiently great; it loses some of its superheat, and if the least drop of it is condensed, condensation immediately progresses with great rapidity. It is this which shows the final hook, attributed at first to piston leaks, in which Professor Heck is still disposed to believe in spite of the irrefutable experimental proof by George Duchesne (Power, previously cited, page 1165). As to this, I shall say a few words hereafter.

Professor Heck's Figs. 5 and 6

In all his statements, Professor Heck assumes the curve of compression to have the same geometrical form as that of expansion, which is never realized in practice. As I have already said, if that were so the question of compression economy would be solved and the hypotheses of Fig. 4 would be useless. In Figs. 5 and 6 there are applied the same arbitrary methods in choosing points, the same want of precision, lack of experimental data—in short, nothing reliable.

Figs. 7 and 8

That in ordinary cases the compression curve falls below the equilateral hyperbola is a simple fiction like the hyperbola itself. The actual fact is that, in ordinary cases, the compression is small and its effect little apparent. It tells nothing either for or against my experiments.

"In the Dwelshauvers-Dery experiments," says Professor Heck, "the engine gave a compression curve like $E\,F$ in Fig. 7; and the whole cycle for the clearance

*Pages 1162 and 1163, Power for June 28.

steam *must have been* of the form *EFGHLE*" there sketched. I greatly doubt that Nature obeys the mandate of Professor Heck, and that it follows the law pv = a constant, to accomplish the cycle. As already stated, this law is never followed in an engine, and is applicable only to perfect gases, which do not exist, and isothermal changes of volume, which are impossible throughout an entire mass inclosed between metallic walls which have no other heat than what they receive from the working fluid.

To pretend to separate the action of the clearance steam from the other by the method which Professor Heck has proposed, is going too far; and I could not approve it unless he based it upon experiments made with large engines as accurately as upon my small one. Our experiments on this latter have shown positively that the steam remaining in the cylinder at the end of the exhaust stroke, in contact with walls hotter than itself, was certainly free from any moisture and probably a little superheated; further, that compression raises the temperature more and more, until, with sufficient compression, it reaches and exceeds that of the walls, following which there may be produced condensation, causing a final hook in the indicator diagram. Are there plausible reasons why the size of the engine should modify these processes? I see none. There is, on the contrary, a reason why the phenomena would have time to take place in one size of engine as well as in another; it is that at the dead-center position the speed of the piston is always nothing.

"There is still some room for skepticism as to the entire absence of leakage from the experimental engine at Liège." Upon what does Professor Heck base this insinuation, the tendency of which is evidently to cast discredit upon our experiments? Upon nothing that has been published concerning this engine, but solely on what relates to the engine of Messrs. Calendar & Nicholson. I feel impelled, then, to inform him that for years, myself believing in loss by reason of the final hook in the compression curve, I did everything possible in order to reveal it, discover it, measure it and avoid it. I procured a fundamental investigation of my engine by the celebrated mechanician Walschaerts, who found nothing more to be said after numerous and careful tests. Having arrived at conviction as to the distribution valves, I wished to examine the piston. For this purpose I ran the engine as a single-acting one, with the rear head removed; holding a light in my hand and following the movement of the piston, I closely scrutinized the entire circumference, clear to the far end, and thus convinced myself that there was no piston leakage within the scope of my senses. Anyone investigating the matter with the same rigor would have arrived at the same conviction. But any reader who has never seen my engine is still capable of defying my statements and maintaining doubt. There was necessary a proof written by the engine itself, an irrefutable witness. It was George Duchesne who furnished it to me, clear, evident, leaving no more room for doubt. Instead of having the engine compress *condensable steam,* he caused it to compress *noncondensable air,* and then all the hook disappeared from the indicator diagram taken in numerous examples. This is stated and illustrated in the issue of POWER above cited, on page 1165.

How does Professor Heck, who seems to believe in his theory, produced purely by his imagination, refuse to give way before a natural, patent, evident fact? If he will only repeat the experiment upon a large engine without leakage, and with sufficient compression of steam to produce a final hook in the diagram, and then will run the engine with the same compression of noncondensable air, he will see that the compression of the air does not produce any hook.

The National Engineers' Convention

The Convention at Rochester was the largest and best ever. The exhibits numbered 175 *and the attendance close to* 1000. *Carl S. Pearse, of Denver, becomes president and Edward H. Kearney, of Boston, was elected vice-president.*

At 10 o'clock Tuesday morning, September 13, the twenty-eighth annual convention of the National Association of Stationary Engineers opened in the armory building at Rochester, N. Y., with a large attendance of delegates and visitors. William J. Ranton, chairman of the local committee, presided over the introductory exercises. The Rev. E. P. Hubbell offered prayer, and the chairman then presented Mayor H. H. Edgerton, who warmly welcomed the convention to Rochester. National President William J. Reynolds responded on behalf of the engineers.

The next speaker was George Dietrich, president of the Chamber of Commerce, who said the growth of the National Association of Stationary Engineers was one for pardonable pride and that its preamble merited such a name as the "Coöperative Brotherhood," because of its endeavors to be valuable in industrial life.

The response to Mr. Dietrich was made by National Vice-president Carl S. Pearse, who told of the discovery of the section of our country now known as the Empire State, alluding to the discoveries of Henry Hudson. Then came a brief review of the colonial period followed by a laudatory account of Fulton's achievement with the "Clermont," America's first steamboat.

Past National President Robert G. Ingleson said that each generation had problems peculiar to its day, and that all methods had been tried, but that the method of the present, that of organization, was the only sane one to get results that promise progress and stability.

The next speaker was Senator George L. Meade, who, after eloquently picturing the importance of the engineer's work in life and what the world owes to him, said he believed that a licensed competent engineer is a far better protection against boiler explosions than any system of inspection that could be devised. Also that the granting of licenses in all professions and trades had elevated the standard of all so licensed. He urged the engineers to stick, even for years, and success must eventually come.

Response was made by E. E. Pruyn, secretary of the New York State Association, National Association of Stationary Engineers, who interspersed the serious portions of his talk with humorous stories.

Before turning over the meeting to National President Reynolds, Chairman Ranton presented the president with a silver-mounted ivory gavel which was accepted with a few well chosen remarks.

The convention was then formally opened. The first order of business being the appointment of the regular convention committees, consisting of:

Ways and Means: F. L. Ray, William H. Sennett, O. S. Wiley, A. A. Garrett and Edward Lawler.

Auditing: John F. McGrath, C. W. Naylor and George W. Brownhill.

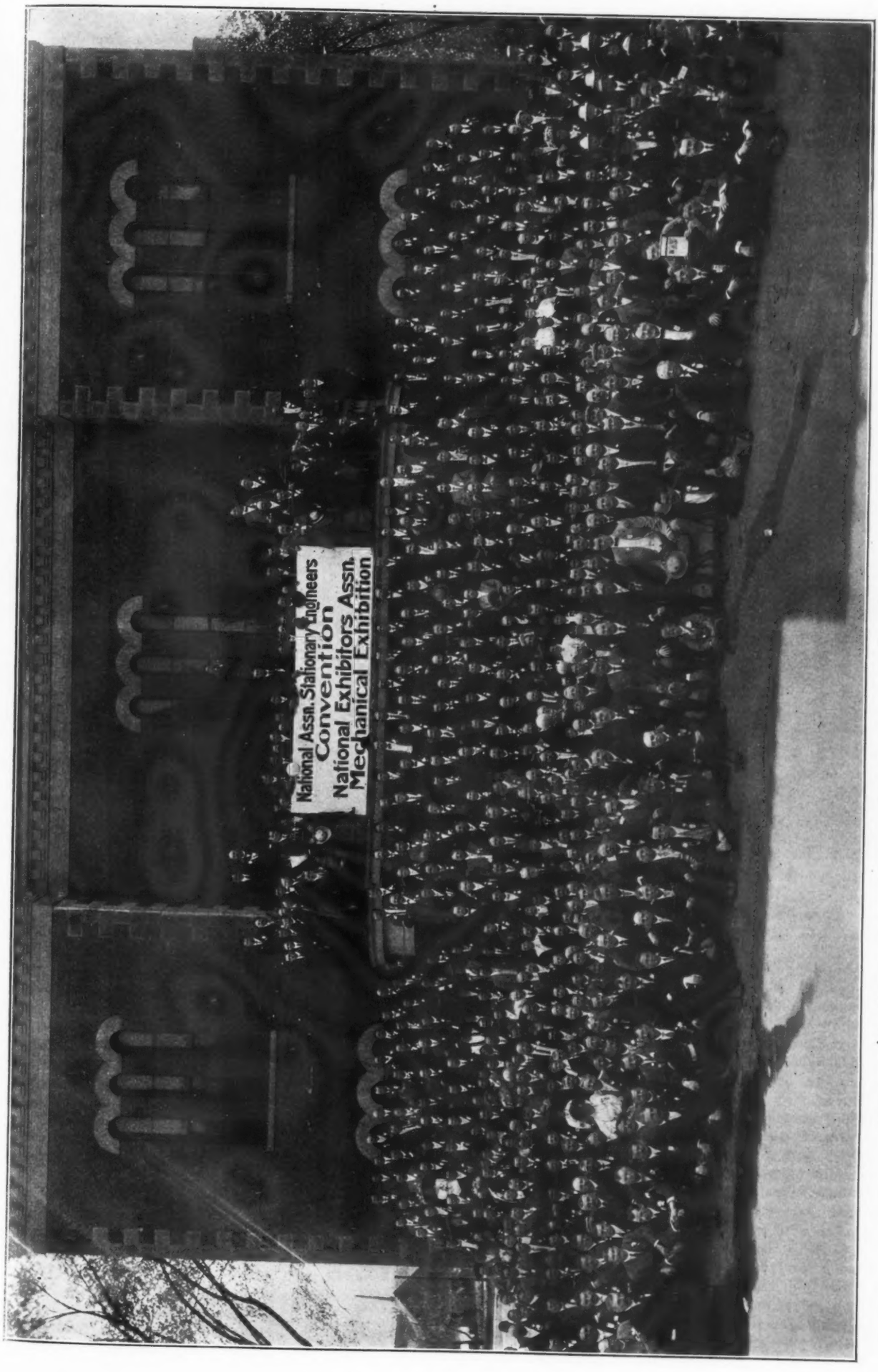
Mileage: J. Singleton, J. W. Varden, Thomas Swayne, George W. Roff and H. F. Morningstar.

Ritual: J. M. Williams, F. H. Munsberg and W. A. Lockett.

Credential: W. P. Weiman, W. V. R. Coon and J. H. Mullen.

The convention then adjourned until 2:30 p.m., and immediately the delegates and guests assembled in the exhibition hall, where National Vice-president Carl S. Pearse in a neat and complimentary address formally opened the exhibit of the National Exhibitors' Association.

The afternoon session convened at 2:25 o'clock. The first order of business was the preliminary report of the cre-



DELEGATES AND VISITORS TO THE NATIONAL ASSOCIATION OF STATIONARY ENGINEERS' CONVENTION AT ROCHESTER, N. Y.

dential committee showing an attendance of 351 delegates.

Then came the annual report of the national president, which was referred to the committee on analysis and distribution.

The report of Secretary Raven showed that he had received and transmitted to the treasurer nearly $25,000. That seven new subordinate associations had been formed and that five had surrendered their charters. Two associations in Connecticut had consolidated as had also two in New Jersey. This report was referred to the auditing committee and was followed by the report of National Treasurer Forse, who reported receipts and disbursements for the year, leaving beside the protection fund a bank balance of over $15,000.

Secretary Raven then read the report of the educational committee which was accepted. The license committee's report covered the past year's work and was promptly accepted and the committee given a vote of thanks.

Invitations were received to visit the power stations of the Rochester Railway and Lighting Company and the Vacuum Oil Company, and the courtesies of the Masonic Club were extended to the delegates.

Permission was given a representative of the National Exhibitors' Association to present a paper to the convention, advocating a better understanding and coöperation between the National Association of Stationary Engineers and the National Exhibitors' Association. The paper was referred to the committee on ways and means. The convention then adjourned until Wednesday morning. At this session the first order of business was the final report of the credential committee giving the list of delegates as 357. An invitation from Adler Brothers to visit their plant was received and accepted, the visit to be made on Friday just after the morning session of the convention.

Proposals to amend the constitution were presented.

A committee was appointed to arrange the proposals which were similar in principle so that the convention could act upon them in an understandable manner and without loss of time, the committee consisting of C. W. Naylor, E. J. Maroney and F. L. Johnson. The committee was instructed to have such proposals printed and distributed to the delegates before their submission to the convention, and thereafter submission to a referendum of the subordinate associations.

At the afternoon session the first matter for consideration was the report of the trustees of the protection fund, which stated that it had not been necessary to expend any of the fund during the past year.

The board of arbitration reported that no cases had come before it for consideration.

Next in order was the report of the board of trustees of the *National Engineer*.

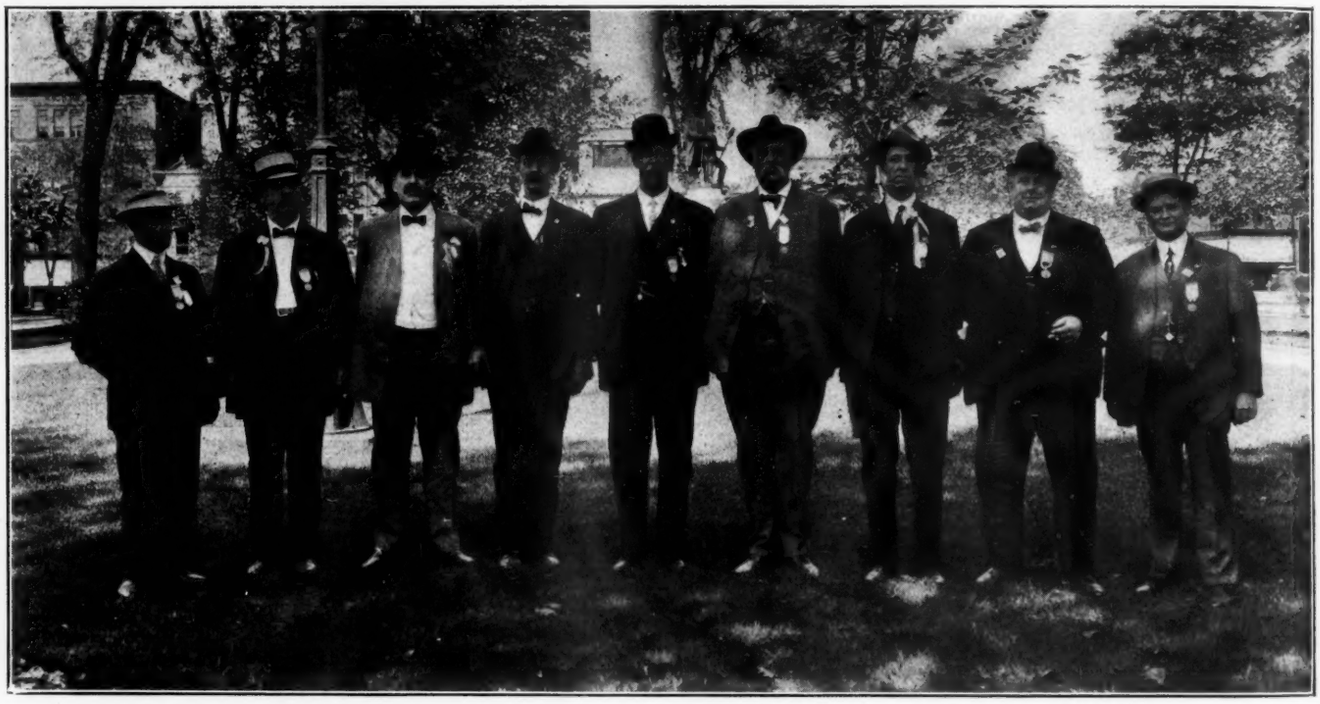
Consideration and discussion of this report was postponed, and attention was given to the report of the pension-fund committee, which was in substance:

There is in the treasury of the Ladies' Auxiliary $4000 which they desire to turn over to the National Association of Stationary Engineers for the purpose of establishing a pension fund. We recommend that this money be received from the Ladies' Auxiliary, to be held in trust by the president, vice-president, secretary and treasurer of the National Association of Stationary Engineers for the specific purpose of establishing a pension or relief fund, until such time as suitable legislation can be enacted by the National Association of Stationary Engineers.

The report was accepted and the recommendation adopted, after which the convention adjourned.

On Thursday morning the delegates listened to the report of the board of trustees. The mileage committee reported the total mileage of the 360 delegates as 249,182.

The privileges of the convention were accorded to the Ladies' Auxiliary. The national president, Mrs. Nella C. Moore, addressed the convention on the question of the pension fund. Among the comments offered was that the convention should make a decision as to the establishment of such a fund, making it



A Group of "Big Ones" at the Convention

Walter E. Sanders, Cleveland, Ohio.
195 lb.—5 ft. 10 in.
Herbert E. Stone, New York City.
267 lb.—6 ft. 2 in.
Louis F. Hoffman, New York City.
296 lb.—6 ft. 4 in.

A. C. Conway, Cleveland, Ohio.
200 lb.—6 ft. 7 in.
A. Van Vredenburgh, Pawtucket, R. I.
244 lb.—6 ft. 8 in.
Theodore Hoff, Chicago, Ill.
274 lb.—6 ft. 7 in.

P. E. Merriman, Methuen, Mass.
220 lb.—6 ft. 4½ in.
James L. Band, Ansonia, Conn.
320 lb.—6 ft. ½ in.
Chester W. Dibble, New York City.
187 lb.—5 ft. 8 in.

part of the association work. She said that referring the matter to a referendum vote was dilatory and very discouraging to those who have for years sought to have the matter placed on a definite basis without unnecessary delay.

A motion was adopted that the president, secretary and treasurer of the National Association of Stationary Engineers be a board of trustees to arrange for the organization of a pension department in conjunction with the officers of the Ladies' Auxiliary.

The next business was the selection of the meeting place of the 1911 national convention, the cities contesting for the honor being Cincinnati, Peoria, Ill., and Mobile, Ala. Cincinnati won by 75 votes over Mobile, its nearest competitor, Cincinnati getting 185, Mobile 110 and Peoria, 6.

Entertainment Features

There were several automobile tours to places of interest through the city.

On Tuesday evening there was a theater party at the Lyceum theater.

On Wednesday evening at the convention hall an entertainment was given by the "Bunch."

On Thursday afternoon special cars conveyed the delegates and guests to Manitou beach. A baseball game was played between the engineers and supplymen, which resulted in a victory for the engineers.

The entertainment features were brought to a close on Friday evening by the usual grand ball, which, on this occasion, was a great success.

Presentations

During the opening session of the convention, National President William J. Reynolds was presented a silver-mounted ivory gavel from the local associations of Rochester.

After the installation of officers on Friday evening, Past National President Reynolds was presented a $250 diamond ring and a past president's jewel.

The members of the New Haven Association, No. 2, of Connecticut, presented delegate Edward J. Maroney with a diamond horseshoe stick pin before his departure for Rochester.

Past President Joseph F. Carney received a handsome clock as a gift from his many friends.

The newly elected vice-president, Edward H. Kearney, was the recipient of a beautiful floral tribute from his admiring friends.

Past National President P. H. Hogan was also remembered by the testimonial-giving crowd.

Nella C. Moore, president of the ladies' auxiliary, was given a valuable cut-glass berry dish.

The George W. Lord Company donated $50 to the Ladies' Auxiliary for their pension fund.

The Seneca hotel was the headquarters of the convention. At the entertainment on Wednesday evening, the proprietor, M. E. Wolf, was tendered a loving cup by the convention guests.

Officers Elected

The national officers elected for the ensuing year were: Carl S. Pearse, president, Denver, Colo.; Edward H. Kearney, vice-president, Boston, Mass.; Fred W. Raven, secretary, Chicago, Ill.; Samuel B. Forse, treasurer, Pittsburg, Penn.; Joseph J. Gibney, conductor, Mobile, Ala.; W. H. Lockett, doorkeeper, Dallas, Tex.

J. D. Taylor was reëlected secretary-treasurer of the life and accident department and the salary fixed at $1200 for the ensuing year. James G. Beckerleg was reëlected to the board of trustees, and was retained as chairman. J. A. Kerley was reëlected to the board of trustees of the *National Engineer*.

The Exhibits

The exhibition of power-plant specialties and supplies held under the auspices of the National Exhibitors' Association was, as usual, one of the most prominent and attractive features of the convention. One hundred and thirty manufacturers occupied one hundred and seventy-three booths in the exhibition hall, which adjoined the convention hall. The entrances were so arranged that the delegates were compelled to pass through the exhibition hall to gain entrance to the hall where the convention held its sessions. This was a most desirable feature from the exhibitors' point of view, and it is hoped that this plan will be adopted at all future conventions.

The exhibition hall was laid out with booths of uniform size but so arranged that two or more booths could easily be thrown into one for those who desired additional space. Wide aisles were laid out so that there was ample passage room between each group of booths. The decorations were uniform in green and white, no other decorative colors being allowed in the hall, making a most pleasing effect. The hall was of limited size so that it was necessary to use two floors for the exhibition.

The following is a list of the exhibitors and their representatives in attendance:

Acheson Oildag Company, Niagara Falls, N. Y. Represented by R. B. Clark, E. G. Acheson, Jr.

Alberger Condenser Company, New York. Represented by S. C. Ross.

Allis-Chalmers Company, Milwaukee, Wis. Represented by R. D. Tomlinson, C. R. Tatem, Rex T. Stafford, F. C. Randall, L. L. Willard, C. A. Burns, A. P. Peck, E. T. Pardee, H. L. Watson, M. H. Merrill, F. G. Bolles, F. S. Sly, W. I. Lucius. They held a guessing contest for the number of blades in a 1000-kilowatt turbine. Sixty sterling silver prizes were distributed.

American Radiator Company, Bundy Department, New York. Represented by W. E. Van Keuren, E. M. Stevens, A. S. Lessen, A. E. Jones.

American Radiator Company, Specialty Department, Chicago, Ill. Represented by E. S. Storm, F. C. Reeder.

American Ship Windlass Company, Providence, R. I. Represented by R. S. Riley, Messrs. Marble, Mallory, Alpern.

American Steam Gauge and Valve Manufacturing Company, Boston, Mass. Represented by N. H. Nickerson, R. S. Pollard. Souvenir; celluloid indicator scale.

Anderson Company, V. D., Cleveland, O. Represented by Joseph H. Meyer, R. E. Bronson.

Arrow Boiler Compound Company, St. Louis, Mo. Represented by F. A. Foster, E. M. Swindler. Souvenir, watch fob.

Ashton Valve Company, Boston, Mass. Represented by Harry Ashton, Columbus Dill, C. W. Houghton.

Austin Separator Company, Detroit, Mich. Represented by H. J. McGregor.

Best Manufacturing Company, Pittsburg, Penn. Represented by Charles K. Thomas.

Bird-Archer Company, New York. Represented by William J. Schatz. Souvenir, link-cuff buttons with official button of the National Association of Stationary Engineers.

Builders Iron Foundry, Providence, R. I. Represented by N. L. Sammis.

Cancos Manufacturing Company, Philadelphia, Penn. Represented by Harry Harmstadt. They held a prize drawing for a gold watch.

Chesterton Company, A. W., Boston, Mass. Represented by H. D. Raymond.

Chicago Die and Stamping Company, Chicago, Ill. Represented by Robert Edwards.

Claflin & Co., Charles A., Boston, Mass. Represented by Charles A. Claflin, Merrill N. Davis.

Cling Surface Company, Buffalo, N. Y. Represented by William D. Young, T. H. Clark.

Cook's Sons, Adam, New York. Represented by M. V. Peavy, George E. Tanberg, W. D. Naughton. Souvenir; pencils, balloons, court plaster.

Crandall Packing Company, Palmyra, N. Y. Represented by John M. Chapman, John Kaymel, Stephen Nauerth.

Crane Company, Chicago, Ill. Represented by J. L. Forsyth, W. L. Oswald.

Crowe Iron Works Company, Paul L., Jersey City, N. J. Represented by Paul L. Crowe.

Davidson Company, M. T., New York. Represented by John Lowe, Thomas Ellerby, Alden L. Corill. Souvenir; paper cutter.

Dearborn Drug and Chemical Works, Chicago, Ill. Represented by Herbert E. Stone, P. H. Hogan, J. N. Gregory, Dan

MEMBERS OF THE NATIONAL EXHIBITORS' ASSOCIATION WHO WERE ON THE JOB AT ROCHESTER

Delaney, J. G. Beckerleg, J. W. Harkins. Souvenirs; perfume and pocket screw driver.

Detroit Lubricator Company, Detroit, Mich. Represented by C. H. Crockett.

Dixon Crucible Company, Joseph, Jersey City, N. J. Represented by L. W. Brooks, John A. Condit, Dudley Thurston. Souvenir; pencils.

Dyna-Como Company, Boston, Mass. Represented by William I. Maude, J. D. Baldwin, D. B. Fox.

Eagle Oil and Supply Company, Boston, Mass. Represented by John L. Hamilton, ably assisted by Mrs. Hamilton. Souvenirs; pocket memo. book, good-luck coin, Perolin noise maker.

Eddy Foundry Company, R. M., Chicago, Ill.

Elliott Company, Pittsburg, Penn. Represented by Henry F. Weinland. Souvenir; pocketbook.

Ernst & Sons, Louis, Rochester, N. Y., representing J. H. Williams & Co., Brooklyn, N. Y., and F. E. Wells & Sons. Represented by August L. Hall, Louis J. Ernst, Joseph L. Ernst.

Fairbanks Company, New York. Represented by L. B. Mann, H. Jeffrey. Souvenirs; hat brush, tape measure.

Federal Metallic Packing Company, Boston, Mass. Represented by C. M. Wheaton, H. W. Rand. Souvenir; joke pocket mirror.

Ferguson Publishing Company, New York. Represented by A. C. Oliver.

France Packing Company, Philadelphia, Penn. Represented by A. W. France, J. F. Boreland. Souvenirs; pencils, stick pins.

Garlock Packing Company, Palmyra, N. Y. Represented by F. P. Morton, F. S. Mosher, F. J. Highmoor, T. C. Green, John N. Todd. Souvenir; leather bill fold.

Goade Water Filter and Purifier Manufacturing Company, Allentown, Penn. Represented by R. J. Goade.

Goulds Manufacturing Company, Seneca Falls, N. Y. Represented by F. T. Wells, H. W. Gumbert, Creed W. Fulton. Souvenirs; steel and celluloid rules.

Gould Storage Battery Company, New York.

Greene, Tweed & Co., New York. Represented by F. E. Ransley, B. M. Bulkley.

Hamler-Eddy Smoke Recorder Company, Chicago, Ill.

Hartford Steam Boiler Inspection and Insurance Company, Hartford, Conn.

Haverstick & Co., Rochester, N. Y. Represented by Frantz Haverstick, Charles Hery, Charles A. Schwonke, Frank E. Lawn, Henry J. Smith, William F. Sullivan, E. M. Keyes.

Hawk-Eye Compound Company, Chicago, Ill. Represented by H. E. Tibbles, Walter Tibbles, R. M. Rochfort, R. S. Everitt. Souvenirs; calendars, watch fob.

Hills-McCanna Company, Chicago, Ill. Represented by Robert E. Hills, Thomas A. Delaney.

Home Rubber Company, Trenton, N. J. Represented by A. R. Foley, Charles H. Swoger. Souvenirs; Foley's fly flowers.

International Acheson Graphite Company, Niagara Falls, N. Y. Represented by Archer C. Gibbons, M. A. Smith. Souvenirs; watch fob, celluloid rule.

International Text Book Company, Scranton, Penn. Represented by J. D. Jones, R. A. Davidson, E. S. Hammond.

Jenkins Brothers, New York. Represented by William G. Le Compte, H. C. McLaughlin, Billy Murray, Charles Beckwith, Frank Martin.

Johns-Manville Company, H. W., New York. Represented by B. C. McClure, E. W. Drew, H. P. Domine, Mr. McKinley.

A. C. Judd, Cleveland, O., representing American Huhn Metallic Packing Company. Represented by A. C. Judd, F. J. Davis. Souvenirs; knife sharpener, pencils.

Kennedy Valve Manufacturing Company, Elmira, N. Y. Represented by William Martin.

Kennicott Company, Chicago Heights, Ill. Represented by W. T. Runcie.

Kent Lubricating Company, Milwaukee, Wis. Represented by L. H. West, J. Morrison Gilmour. Souvenir; flag pin.

Kerbaux Company, New York. Represented by Irving D. Lyon.

Keystone Lubricating Company, Philadelphia, Penn. Represented by C. A. Hopper, T. W. Armstrong, H. L. Carpenter, A. D. Page, M. B. Urquhart. Souvenirs; clothes brush, cap.

Kitts Manufacturing Company, Oswego, N. Y. Represented by Arthur S. Light, T. N. Malcolm, Houston Hill, W. A. Kitts. Souvenir; celluloid rule.

Lagonda Manufacturing Company, Springfield, O. Represented by M. M. Sellers, James H. Johnson, J. P. Maloy, M. O. Lewis, W. J. Patterson, Hart Hill, C. F. Overly. Souvenir; watch fob.

Lake Erie Boiler Compound Company, Buffalo, N. Y. Represented by E. C. Schwingel, J. R. Pratt, George J. Juhre. Souvenirs; celluloid rule, pencil cigar.

Liberty Manufacturing Company, Pittsburg, Penn. Represented by H. A. Pastre, Karl Sixt. Souvenir; pocket book.

Lippincott Steam Specialty and Supply Company, Newark, N. J. Represented by A. C. Lippincott. Guessing contest for a complete indicator outfit.

Lloyd Manufacturing Company, Menominee, Mich. Represented by C. N. Dalrymple.

Lord Company, George W., Philadelphia, Penn. Represented by Edward McCarthy, B. L. Lord, Roy Downs, H. L. Gaskell.

Lunkenheimer Company, Cincinnati, O. Represented by Lane Thompson, assistant sales manager; W. W. Beal, A. S. Phillips, William Schmidt, Jr., E. P. Gould. Souvenir; cloth cap.

Lyons Boiler Works, De Pere, Wis. Represented by W. P. Lyons.

McCrea & Co., James, Chicago, Ill. Represented by M. B. Skinner.

McLeod & Henry Company, Troy, N. Y. Represented by John H. Foote, Charles N. Morgan. Souvenir; 2-foot folding boxwood rule.

McVicker Company, W. B., New York. Represented by W. B. McVicker, John McDonald. Souvenirs; card case, silver collapsible drinking cup.

Manning, Maxwell & Moore, New York, representing Ashcroft Manufacturing Company, Consolidated Safety Valve Company, Hayden & Derby Manufacturing Company, Hancock Inspirator Company. Represented by L. M. Brigham, Frank J. Corbett, Harry B. Aller, W. P. Bradbury, C. Monroe Smith.

Mason Regulator Company, Boston, Mass. Represented by Eldon MacLeod, Frank M. Morrison.

Mechanical Rubber Company, Cleveland, O. Represented by H. T. Fryant, Charles B. Iler, A. C. Conway, R. F. Valentine. Souvenirs; pipes, glass and stein mats.

Michigan Lubricator Company, Detroit, Mich. Represented by W. E. Bryant.

Mining World, Chicago, Ill. Represented by J. Winchester Holman.

Monarch Valve and Manufacturing Company, Springfield, Mass. Represented by R. E. Brown.

National Engineer, Chicago, Ill. Represented by Robert E. Larkin, L. L. Rice, John W. Lane, W. T. Mug.

Neemes Brothers, Troy, N. Y. Represented by Spencer Neemes, Oscar G. Neemes.

Nelson Valve Company, Philadelphia, Penn. Represented by Carlisle Mason, R. Bonnell, W. J. Spencer, R. E. Thomas, G. E. Huxley.

New York Belting and Packing Company, Ltd., New York. Represented by Charles A. Wilhoft, Carl P. Kock, F. E. Friedlander. Souvenirs; knife, Manual of Steam Engineering.

North Brothers Manufacturing Company, Philadelphia, Penn. Represented by F. A. Mutchmore.

New York & New Jersey Lubricant Company, New York. Represented by J. D. Kelrie. Souvenir; pipe and tobacco.

Ohio Blower Company, Cleveland, O. Represented by H. H. Lind.

Ohio Brass Company, Mansfield, O. Represented by W. T. Jameson, C. N. Allerding.

Ohio Grease Lubricant Company, Londonville, O. Represented by F. W. Rogers, J. C. Ross, George A. Mull. Souvenir; postal cards.

Osborne High Pressure Joint and Valve Company, Chicago, Ill. Represented by W. L. Osborne, C. M. Schneider, W. A. Tilley.

Otis Elevator Company, New York. Represented by E. R. Pike.

Peerless Rubber Manufacturing Company, New York. Represented by Stephen Roberts, Charles Heitzmann, H. L. Brown,

J. Voltz, F. E. Bigelow, James Mason. Souvenir; watch fob.

Penberthy Injector Company, Detroit, Mich. epresented by F. O'Leary, Edwin Robinson. Souvenirs; watch fob. memo book, steel tape measure.

Peterson Engineering ompany, New York. Represented by J. W. Peterson.

Philadelphia Grease Manufacturing Company, Philadelphia, Penn. Represented by T. Addison Collins, Horace A. Smith. Souvenir, postal cards.

Positive Differential System Company, New York. Represented by James A. Donnelley, Charles A. Fuller.

POWER. Represented by John A. Hill, Jack Armour, William Van Kleeck, Charles N. Beard, H. K. Fisher, Fred L. Johnson, R. S. Richardson, J. D. Tighe, H. E. Cleland, Chester W. Dibble. Souvenir; identification badges.

Powell Company, William, Cincinnati O. Represented by Charles E. McFarlin, Charles Cullen, W. J. Leonard. Souvenir; watch fob.

Practical Engineer, Chicago, Ill. Represented by E. R. Shaw, A. L. Rice, C. S. Clarke, C. B. Leech, S. W. Anness, John A. Kershaw, H. W. Williams. Souvenir; memo book with directory of the exhibits.

Quaker City Rubber Company, Philadelphia, Penn. Represented by W. D. Purcell, S. B. Johnson. Souvenir; watch fob.

Restein Company, Clement, Philadelphia, Penn. Represented by A. H. Foster, D. D. Fernell. Souvenir; watch fob.

Revere Rubber Company, Chelsea, Mass. Represented by J. W. Dugeon, R. C. Whitmore, E. D. Lombard, J. W. Lawrence. Souvenirs; memo book, watch fob.

Richardson-Phenix Company, Milwaukee, Wis. Represented by Robert R. Keith, J. S. Ward, T. M. Walton, Mr. Tomlinson.

Ridgway Dynamo and Engine Company, Ridgway, Penn. Represented by R. C. Eccleston, Peter G. Rimmer.

Rochester Rubber Company, Rochester, N. Y. Represented by H. L. Dusky, F. E. Bigelow, G. N. Wilkinson.

Roebling's Sons Company, John A., New York. Represented by John W. Troescher, G. W. Swan.

Ross Valve Manufacturing Company, Troy, N. Y. Represented by William Ross, Adam Ross, J. C. Ross.

Ryerson & Sons, Joseph T., Chicago, Ill. Represented by D. M. Ryerson, J. T. Corbett, G. D. Branston. Souvenir; paper weight.

S-C Regulator Company, Fostoria, O. Represented by N. G. Copley, John F. Robertson.

Scully Steel and Iron Company, Chicago, Ill. Represented by John H. Allen, F. C. Farnsworth, W. H. Dangel.

Standard Oil Company of New York. Represented by C. A. Salisbury, C. S. Thayer, G. E. Roe, F. L. Damon.

Sterling Lubricator Company, Rochester, N. Y. Represented by John Buckley, F. C. Bulkley.

Sterling Oil Company, Rochester, N. Y.

Strong, Carlisle & Hammond Company, Cleveland, O. Represented by F. H. Evans, A. B. Pinney, C. H. Camp, J. C. Murdock, Homer Whelpley, L. P. Strong, F. S. Palmer, Charles Van de Velde. Souvenir; caps.

Southern Engineer, Atlanta, Ga. Represented by J. Willett Smith, W. S. Cushion, Lewis L. Warren, W. S. Dobie. Souvenir; cotton boll.

Squires Company, C. E., Cleveland, O. Represented by C. E. Squires. Souvenir; memo book.

Thacher & Co., George H., Albany, N. Y. Represented by C. T. Coe.

Thermoid Rubber Company, Trenton, N. J. Represented by Fred Kuhl. Souvenir; packing knife.

Trill Indicator Company, Corry, Penn. Represented by W. L. Trill, L. T. McElroy. Souvenir; hook and cord adjuster.

Under-Feed Stoker Company of America, Chicago, Ill. Represented by W. T. Johnson, W. R. Faber. Souvenirs; memo book and card case, ladies' shopping list.

Underwood & Co., H. B., Philadelphia, Penn. Represented by Edwin J. Rooksby, Edmund C. Crawford. Souvenir; book of useful hints for engineers.

Union Oil Works, Rochester, N. Y.

United States Graphite Company, Saginaw, Mich. Represented by F. J. Lee, G. N. Southard. Souvenir; pencils.

Universal Lubricator Company, Philadelphia, Penn. Represented by J. F. Lewis. Souvenir; playing cards.

Vanda Company, New York. Represented by Hudson Dickerman, Messrs. Hasenderer and Kascher. Souvenir; watch fob.

Von Kokeritz & Co., R. G., New York. Represented by J. A. Carson, Harry Wigley.

Warren Lubricant Company, New York. Represented by Albert J. Squier, M. M. Sanderson, F. P. Greenlund.

Westinghouse Air Brake Company, Pittsburg, Penn. Represented by M. H. Burchard, F. H. Parke, S. H. Mills, H. B. Bradford, H. E. Chilcoat. Souvenir; cuff buttons.

Westinghouse Electric and Manufacturing Company, Pittsburg, Penn. Represented by E. D. Kilburn. Souvenir; cuff buttons.

Westinghouse Machine Company, Pittsburg, Penn. Represented by R. A. Miller, G. D. B. Van Tassel. Souvenir; cuff buttons.

Wickes Boiler Company, Saginaw, Mich. Represented by James Milne, C. F. Wilson.

Williams Company, G. H., Cleveland, O. Represented by G. H. Williams.

Williams Gauge Company, Pittsburg, Penn. Represented by C. E. Wolff, Jr., F. E. Cox.

Williams Valve Company, D. T., Cincinnati, O. Represented by H. J. Ernst, D. T. Williams, L. W. Kramer, Charles Becker. Souvenir; combination pocket book and card holder.

Wright Manufacturing Company, Detroit, Mich. Represented by H. J. McGregor.

Ziermore Regulator Company, Johnsonburg, Penn. Represented by W. E. Zierden.

The election of officers for the National Exhibitors' Association resulted as follows: President, William D. Purcell, Quaker City Rubber Company; vice-president, Harry H. Ashton, Ashton Valve Company; secretary, Homer Whelpley, Strong, Carlisle & Hammond Company; treasurer, W. T. Johnson, Under-Feed Stoker Company of America; executive committee, Lane Thompson, Lunkenheimer Company; M. B. Skinner, James McCrea & Co. L. B. Mann, Fairbanks Company; H. D. Raymond, A. W. Chesterton Company; H. A. Pastre, Liberty Manufacturing Company.

At the regular meeting of the National Exhibitors' Association on Thursday evening, September 15, the retiring president, William G. Le Compte, was presented with a very handsome gold watch and fob with the various Masonic emblems, Mr. Le Compte being a thirty-second-degree Mason. The presentation speech was a most happy one, delivered by Arthur L. Rice, editor of the *Practical Engineer*.

One of the other pleasant features was the presentation on Friday of a beautiful gold-headed cane to "Dick" Foley, of the Home Rubber Company, by a number of admiring friends among the exhibitors. The presentation took place at the Home Company's booth, with a neat speech by J. Winchester Holman, of the *Mining World*.

Only Partly Watt

On a visit to Birmingham, we were informed that there was running at the works of Gillott & Sons, the well known steel-pen manufacturers near that city, an old steam engine supplied by Watt & Boulton. Application for photographs and particulars brings out the information that all that is left of the original Watt engine is the spear connecting rod and the flywheel. The cylinder, slide valve and parallel motion are of modern construction, the old Watt piston and valve having been replaced in 1886 by Buckley's piston and cylindrical slide valve, with relief valves of that date. The engine in its present form is working very satisfactorily with a boiler pressure of only 26 pounds and developing 60 horsepower.

In 1902, Russia produced 2,000,000 tons of peat fuel. This quantity is more than any other nation produced in that year.

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Power and The Engineer

Editorial

The Rochester Convention

The twenty-eighth annual convention of the National Association of Stationary Engineers at Rochester, September 13-16, has gone into history as the largest and most successful ever held by the organization. There were in attendance three hundred and sixty delegates from forty-one States and the District of Columbia. There were present the representatives of one hundred and thirty manufacturers who occupied one hundred and seventy-five booths in the exhibit hall. Beside these there were also friends and guests who brought the total number attending the convention considerably above the one-thousand mark.

The approximate cost of this convention estimated from the reports of the treasurer and mileage committee was $13,000, which, of course, does not include the individual expenses of the delegates nor the sums appropriated by the subordinate associations for convention purposes.

What it costs the manufacturers to display their products in the booths, to distribute souvenirs and the customary, as well as the unusual, hospitality that was occasionally extended may not be so easily guessed, nor is it of much importance, as it is generally understood that the exhibitor gets full value in the advertising and publicity attendant upon such occasions.

But does it pay the association to hold annual conventions? As the initiative and referendum method of legislation which was adopted some years ago has reduced the necessary work of the convention to the accepting or rejecting the reports of its officers and committees, to fixing the amounts that shall be paid to delegates and officers, and the election of officers, the question does it pay often comes to the front.

In the preamble to the constitution it is stated that preference shall at all times be given to the education of engineers. While the social events which occupy a large portion of the delegate's time, and the examination of the mechanical exhibits coupled with the duties attending the convention sessions are in a broad sense educational, there are many who favor either biennial conventions or such changes in the constitution as will permit of representation by a much smaller number of delegates elected from State associations.

Either of these changes, it is argued, would leave in the treasury at least $10,000 which could be profitably expended in helping the weaker associations, in employing lecturers and in other ways developing and improving the educational features of the organization and for which it was founded.

In the convention the question of paramount importance is the selection of a vice-president for the ensuing year. To be sure this is framed about by excursions to points of interest, by attendance at entertainments, dinners, social gatherings and the selection of a city in which to hold the next convention, but the *piece de resistance* is the election of this officer.

Is it worth the price?

License Laws

We put a gate at the head of a flight of stairs so that the baby cannot fall down and cause anguish and dismay all through the family. We did not do this because we suspected that the baby had any deliberate intentions of barking himself up. We did it to protect him from his ignorance.

The child is father to the man—and frequently brother too. That is to say, like Peter Pan, some of us never grow up. We need "gates" in the form of life lines at the seashore; bells, barriers and flagmen at the railroad crossing; automobile speed laws, and don't-blow-out-the-gas signs as well as a thousand and one warnings not to do this or to be careful about that, all to protect us from ourselves.

The enactment and enforcement of license and inspection laws constitute a "gate" to protect the public and the mentally infantile power-plant owners and operators from their own ignorance. With thorough license laws in force, none but those with the proper mental equipment would be allowed to hold positions as engineers. We have specified only proper mental equipment, for it is perfectly safe to leave the matter of proper physical equipment entirely to the man who does the hiring.

It is sure that he will not take on any one-armed firemen or blind engineers, any more than a person who had a pig in an alley to catch would get a man with parenthetical ( ) legs to do the trick. Would that the employer could be as thoroughly depended upon to hire men properly qualified mentally.

When every State has a good license

and inspection law or when there are thorough Federal laws—and we believe that either the former or the latter are surely coming—we will have to cast about for a new stock topic for editorial comment. In a way, we shall regret this, for the present one has been with us long and ever active.

On page 1739 in this issue a correspondent expresses a line of logic which is naive. We are not going to answer a single sentence for we feel that anything which we might say would be quite superfluous. He makes us think of the two men who had been watching a free street parade which was given by a circus. One of the men was a pessimist. When the other man asked him what he thought of the parade, he replied that it was no good and ought to be prohibited. He claimed that his wife and children would see it and then want to go to see the circus, and there is where they would get him. In fact, it was nothing but a scheme to get money.

So with the correspondent just referred to, he thinks that license laws are nothing but a scheme of some men to get the jobs of others.

Economic Engineering

During the past summer, New Yorkers have witnessed the spectacle of a sixteen-story office building, which had been erected about twelve years, being torn down to make room for a still taller building. Apparently the trend of modern practice is to discard anything which can be replaced by a more efficient substitute, insuring an increased return upon the investment.

This practice is not by any means confined to the building trades; in fact, its greatest field of application is to be found in the generation of power. Here, engines, which only a few years ago were considered to have approached very closely the goal of perfection, are now being replaced by new prime movers which will meet the increasing demands for power with a higher efficiency. Boilers, mechanical stokers, auxiliaries, oiling systems, etc., are subjected to the same treatment. But not alone is the equipment affected, the methods of operation are also undergoing a transformation; the tendency, especially among the larger plants, being to combine scientific results with practical operation, to systematize methods, and to effect a suitable system of keeping records and costs, so that the performance of the plant may be known at any time.

With the exigency for such methods a new field in engineering has been created, employing what may be termed the "economic engineer." The duties of this class of experts are to carefully investigate the conditions existing at the plant under consideration, view the proposition from all sides, devise schemes whereby the equipment and methods of operation can be improved and made more efficient, and submit a report to the owners, setting forth such recommendations as will accomplish the desired result. The economic engineer is in a much better position to produce an effective solution of the problem than the superintendent or the chief engineer, because with the latter it is often very hard to break away from long established customs, while the economic engineer is free from local prejudice and has a vast amount of data, collected from various other plants, to aid him in making intelligent recommendations.

Another Chance for Investors

The latest institution to philanthropically offer a magnificent chance for riches to the widows and orphans and hard-working mechanics, is the National Mechanical Power Company, 1548 East Sixty-third street, Chicago, Ill.

The perpetual-motion scheme which this company is propagating is the old, old one of falling weights on the periphery of a wheel, the weights being returned to their starting place at a point on the wheel less distant from the center. Exactly the same number of weights are ascending and descending at all times, but owing, of course, to the "new principle" which has been discovered by the inventor, the wheel is enabled to give out an excess of power over that required to raise the weights, limited only by its diameter and the number of weight systems employed.

The operation is explained as follows: "Each wheel has two rows of pockets, the inner row, called the short side and the outer row, the long side. The wheel is made to revolve by falling balls. When a ball has passed up the short side to the top, it rolls out into a triangular conduit, which is fast on the side of the wheel, and rolls down into the outer row of pockets. After it has reached a point near the bottom of the wheel it passes through another conduit back into the inner row of pockets and is elevated to the starting point, thereby making the *gravity* greater than the *levity*."

It is needless to say that a working model of this device has not yet been produced, although various mysterious patterns and parts lay about the office of the concern, upon the walls of which are plastered numerous blueprints showing the "simple principle" on which the thing works.

The excuse for not exhibiting a working model is said to be totally in the interests of those who are about to invest in the stock of the concern, as after the model has been exhibited the stock will, of course, jump three or four hundred per cent. Therefore, it behooves all the innocent, nontechnical parties who have not yet been "soaked," to get in on the ground floor immediately.

Why Use Compression?

The subject of compression is not new. It has been discussed for years by engineers, engine builders and college professors, but today the question is very little nearer being settled than it ever was.

Many thinking men have taken a pad of paper and a pencil, and after plotting diagrams, some of which could not be obtained in actual practice with the steam and exhaust valves properly set, have undertaken to prove that compression is advantageous.

Other thinking men, men with engines before them, have not wasted their time with pad and pencil, but have experimented with their engines and found that with valves set to give a late steam admission and practically no compression the steam plant could be operated on less coal than when the engines were operated under high compression.

Men are a great deal like sheep—they are prone to follow a leader. Someone has decided that compression is necessary for smooth running and for the highest efficiency, and the idea has been generally accepted by engineers. They have taken the teachings of others as facts without questioning the accuracy of the statements, although at the same time they have had the means of proving or disproving, to their own satisfaction at least, that compression is, or is not, economical.

Engineers who have taken interest enough in their work to make tests, although demonstrating to their own satisfaction that compression is expensive to maintain, and have proved it by the difference in the fuel bill of their own plants, have received more or less criticism from others holding a different view.

But the strange part of it all is, that, while column after column has been published in the technical journals, criticizing the practice of not using compression, not one of the critics, so far as we know, has verified his contention by proving from actual experiments on a real engine that his theory is correct. And so the question is juggled from time to time and nothing definitely accomplished.

A few experiments in valve setting would do much to prove or disprove the contentions of those holding different views on the question, providing the tests were impartially and carefully made.

The engineer, or the man who pays the bills, does not care much for the paper and pencil end of the argument; but they do care about the money that can be saved in operating a steam plant, and would much rather see figures obtained from actual operation. It would seem that the proper place to carry out these experiments is in the laboratory of the technical institution. When this is done, some interesting and reliable data will be obtained.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it.

Condensing Water Required

I have a compound noncondensing engine which I wish to run condensing. The boilers evaporate about 1000 cubic feet of water per day. How much water will be needed to condense the steam?

G. E. B.

The quantity of injection water will vary with the conditions; such as the temperature of the exhaust, the temperature of the water, the degree of vacuum and whether a jet or a surface condenser is used. Under ordinary circumstances the amount of injection water required will probably be 30 times the weight of the steam exhausted, which in this case will be 30,000 cubic feet, or about 19,000,000 pounds.

Independent Condenser

What is an independent condenser and in what manner does it differ from any other?

J. R.

When the term independent is used it refers to something that acts independently of other machinery. As applied to condensers it is a misnomer as it is the air pump to which reference is made, and while it may be operated by itself independently of the engine, it is called independent to distinguish it from one operated by the engine it serves.

Capacity of Coal Bunker

A coal bunker is 137 feet long, 12 feet wide and 15 feet deep. How much soft coal will it hold level full?

M. B. C.

There are in the bunker

$$15 \times 12 \times 137 = 24{,}660$$

cubic feet. The weight of loose soft coal varies from 45 to 55 pounds per cubic foot. Taking 50 pounds as the average weight, 40 and 44.8 respectively will be the space occupied by a short and a long ton, and the bunker will hold

$$24{,}660 \div 40 = 614 \text{ short tons.}$$

$$24{,}660 \div 44.8 = 550.5 \text{ long tons.}$$

Crank-pin and Piston Travel

Which travels faster, the crank pin or piston of an engine?

A. M. D.

The crank pin moves over the semicircumference of a circle, while the piston moves through the diameter of the same circle, hence the pin travels faster.

Cost of Exhaust Steam Heat

Does it cost more to heat with exhaust steam than with live steam?

E. A. D.

Not necessarily, nor usually. An exhaust steam-heating system may be so designed that there will be little or no back pressure in the engine cylinder and all the heat got from it will be practically clear gain.

Steam Pressure and Hight of Water Column

If the steam pressure in a boiler is 80 pounds, how high will it force water in a one-inch pipe attached to the bottom of the boiler?

B. L. S.

If the water in the pipe is of the same temperature as that in the boiler it will be forced to a hight of 200 feet.

Horsepower of Boilers

What is the proper rule for computing the horsepower of a boiler?

J. A. S.

The "Centennial Rule," which requires that a boiler shall evaporate 30 pounds of water into dry steam from feed water at 100 degrees under a gage pressure of 70 pounds per square inch for each horsepower. It is equivalent to the evaporation of 34½ pounds of water from and at 212 degrees. There should be 10 square feet of heating surface in a boiler and ¼ to ⅓ square foot of grate area in the furnace for each horsepower.

Key Seat in a Split Pulley

Where is the right place to put the key in the hub of a split pulley?

F. R. T.

Keys are not necessary in split pulleys in which the bore of the hub fits the shaft properly. If a key seat is desired, it is usually cut at the middle of one of the halves of the hub and a feather is used instead of a key.

Engine Horsepower

What is the indicated horsepower of a 10x18-inch engine running 150 revolutions per minute; 100 pounds initial pressure per square inch in the cylinder cutting off at quarter stroke and exhausting into a heating system against 10 pounds back pressure?

C. W. D.

The mean forward pressure of the steam in the cylinder is practically 0.6 of the initial pressure or 69 pounds absolute per square inch. The back pressure is

$$10 + 15 = 25$$

pounds absolute, which, deducted from the 69 pounds absolute forward pressure, leaves

$$69 - 25 = 44$$

pounds mean effective pressure per square inch in the cylinder. The piston speed is 450 feet per minute and the area of the piston is 78.54 square inches. The horsepower of an engine is expressed by the formula

$$\frac{P.A.S.}{33{,}000} = \textit{Horsepower}$$

where

P = Mean effective pressure:

A = Area of piston;

S = Feet of piston travel per minute.

Substituting

$$\frac{44 \times 78.54 \times 440}{33{,}000} = 45.72$$

indicated horsepower.

Safety Valve Rule

What is a safe rule for finding the pressure at which the safety valve should blow on any boiler?

J. G. R.

Calculate the bursting pressure of the boiler and set the valve to open at one-sixth of that pressure.

Meaning of the Term "Battery"

What is meant by the word "battery" when applied to boilers?

F. J. H.

It means that two or more boilers have a setting common to all and discharge steam into the same main steam pipe.

Evaporation per Pound of Coal

If a boiler evaporated 10.25 pounds of water per pound of coal containing 13,900 B.t.u., how much would have been evaporated per pound of coal containing 14,200 B.t.u. per pound?

J. C. D.

As it was the heat that evaporated the water a coal having more heat units would evaporate water in proportion to the excess in heat units. Hence

$$\frac{14{,}200}{13{,}900} \times 10.25 = 10.465$$

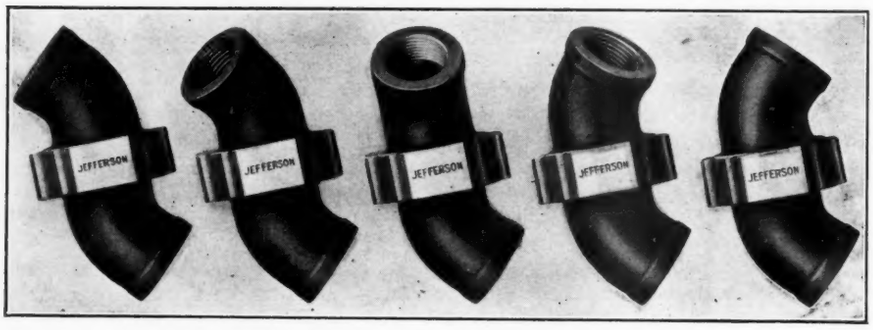
pounds of water would under the same conditions have been evaporated for each pound of coal containing 14,200 B.t.u.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news.

Jefferson Swing Union

The new swing union, made by the Jefferson Union Company, Lexington, Mass., consists of two 45-degree elbow parts with a spherical ground iron-to-iron seat. The two ends are connected by a nut of either brass or malleable iron. These unions can be made with the regular Jefferson brass-to-iron seat, which consists of a narrow brass wrought-metal ring sunk in a channel in which it fits tightly. A lip of iron protects the brass ring from contact with the fluid, and also from injury, should the pipe be screwed in too far. For close work the Jefferson swing union can be equipped with a special notched nut.



VARIOUS POSITIONS OF JEFFERSON SWING UNION

The accompanying illustration shows the union in various positions, the joint always being tight regardless of the angle of connection.

By using an iron-to-iron seat these unions can withstand the high temperature of the exhaust from gas or gasolene engines.

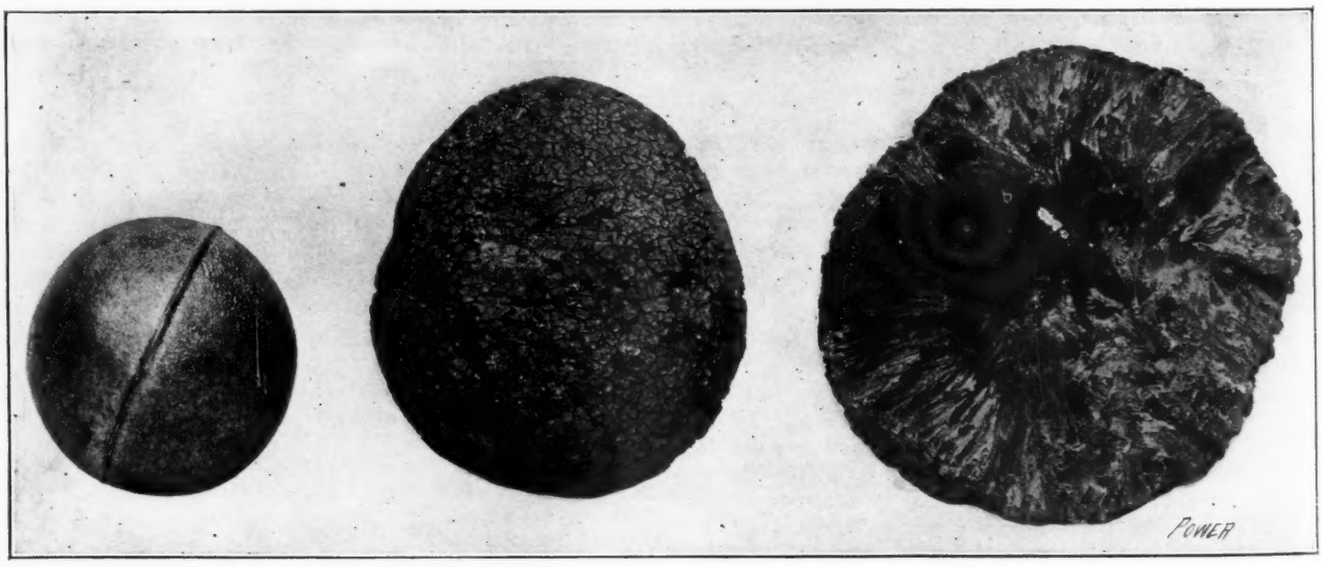
Metallic Boiler Cleaner

In our issue of August 3, 1909, brief mention was made of a new boiler cleaner placed upon the market by the Connecticut Metal Boiler Cleaner Company, of New Haven, Conn. Since then we have come into possession of more definite information upon the subject.

The device consists of a number of metallic balls contained in a cast-iron basket which is suspended just below the water line in the boiler. The composition of the balls is zinc, antimony, aluminum, bismuth, copper, lead, tin and mercury. Each ball does not contain all these ingredients, nor are the proportions the same. With zinc (which is frequently used in marine work to prevent scale) as a basis, the balls are divided into eight groups, each containing zinc alloyed with various combinations of the other metals. It is claimed that the other metals hold the zinc in solution for different periods under various conditions of pressure and temperature; hence, a ball of the first group may be disintegrated in, say, three weeks, one of the next group a week later, and so on, the action of all the balls in the basket extending over a period of several months. The quantity of the metal compound and the proportion of the ingredients entering into its composition depend upon the horsepower of the boiler and the quality of the water. Only in extreme cases is the group containing mercury used.

It is claimed that the compound will prevent the formation of new scale and will loosen old scale by setting up a galvanic action which causes bubbles to form between the boiler plate and the scale, thus loosening the latter.

The accompanying photograph shows one of the metal balls, first in its original state before being placed in the boiler; next, its condition after having been in the boiler for about three weeks; and finally its appearance after having been in the boiler for five weeks.



BEFORE AND AFTER BEING PLACED IN BOILER

A personal canvass among the users of these metallic balls has met with a number of very favorable testimonials, and a few that were unfavorable.

The Hopper Steam Turbine

The object of this invention is the production of a steam-turbine engine in which effective and simple means are utilized for obtaining an efficient operation for a wide range of loads. Means are also utilized for automatically varying, in accordance with the load demand, the effective number of operating steam supply nozzles.

The steam passages are so arranged that the steam may traverse the entire system at an average velocity without being restricted at any point. The area of the nozzles gradually increase in width, and the movable and fixed vanes in depth. Steam in passing through them is prevented from acquiring its full theoretical velocity from the perpendicular pressure used by its action on the vanes.

The turbine shown in the accompanying illustrations is of the multistage type in which steam is admitted at the middle and flows in opposite directions to the exhaust openings.

Fig. 1 shows a sectional elevation of the turbine. Fig. 2 is a longitudinal section and Fig. 3 shows an edge and face sectional detail view of the vanes. Fig. 4 presents a detail of the vanes showing the enlargement of the steam areas between them, also a top view showing the curved form of the vanes. Fig. 5 shows an enlarged sectional view of one of the nozzle-controlling valves, also a face view of a valve seat.

The turbine comprises a series of rotors rigidly mounted on a shaft which extends through the heads of an exterior casing, and is journalled in suitable bearings formed integrally with the heads.

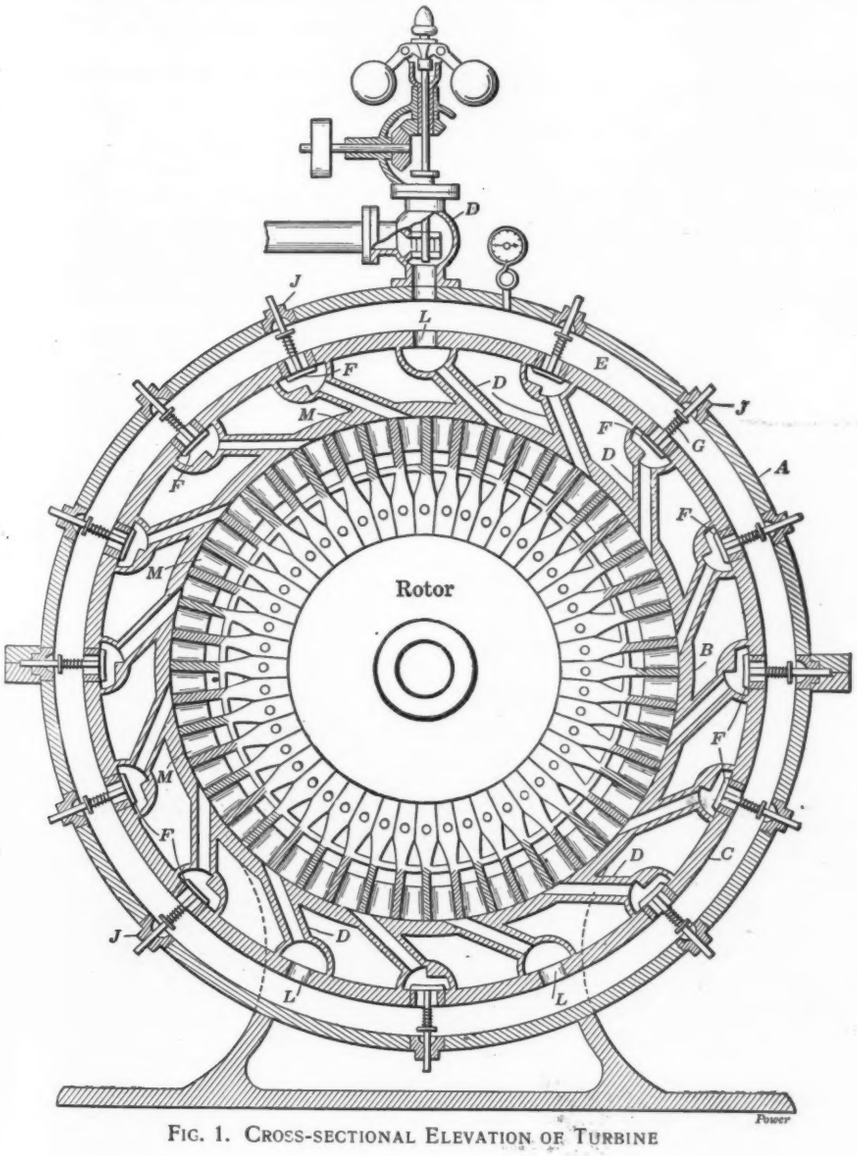


FIG. 1. CROSS-SECTIONAL ELEVATION OF TURBINE

An annular steam chest *A* surrounds the casing *B* and is divided by an annular ring *C*, from which extends divergingly downward a series of steam passages or nozzles *D* that communicate with the inner chamber of the casing *B*. Between *A* and *C* is an annular space *E* that is supplied with steam by a suitable governor through an opening on the top of of the casing. This governor controls the operation of the valves *F*, which are adapted to open or close independently by a varying steam pressure, and are so arranged that steam in the chamber *E* opens the valves *F* against the action of a spring *G*. The valve rests against a seat threaded into the ring *C*. On the

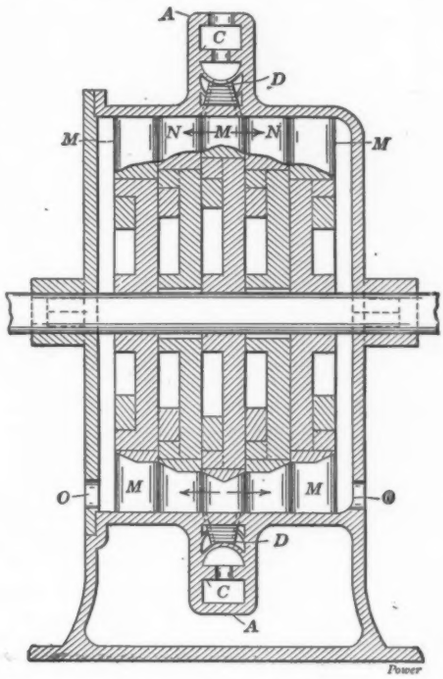


FIG. 2. LONGITUDINAL SECTIONAL VIEW OF TURBINE

stem of the valve is a lock nut *E*, Fig. 5, by which proper tension is given to the spring. The plugs *J* are of larger diameter than the valve seats. They are threaded into the steam chest and are provided with a stuffing box *K*. The three nozzle openings having no controlling valves, permit an unobstructed flow of steam from the chamber *E* through the respective nozzles with which they are connected. Under a very light

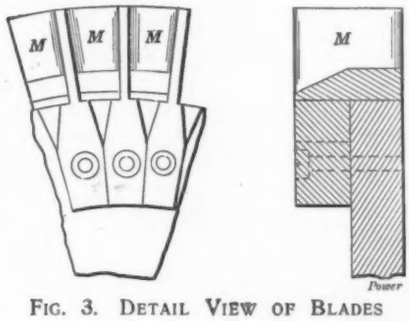


FIG. 3. DETAIL VIEW OF BLADES

load these nozzles would supply all necessary steam to the turbine. and the throttling governor would regulate its speed by the admission of steam to the chamber *E*.

As the load on the turbine increases, the steam pressure in the chamber becomes greater, and the nozzle-controlling valve having the least spring tension will open, admitting more steam to the tur-

bine; a further increase of the load opens another valve in a similar manner and so on until all the nozzles are supplying steam and the turbine attains its maximum power. Should the amount of load decrease, a proportionate number of the

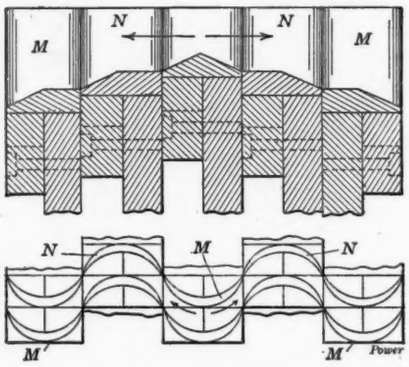


FIG. 4. VANE DESIGN

valves would automatically close, permitting only a sufficient number of active steam-supply passages to economically operate the engine.

Steam is expanded in the nozzles *D*, its pressure energy thereby being partly transformed into velocity energy, and is made use of by passing it in either direction through the vanes *M* of the rotors, as indicated by the arrows in Figs. 2 and 4 Between each pair of rotors is inserted a set of stationary guides or vanes *N*, Fig. 4, for the purpose of receiving and reversing the steam, discharged from a rotor, and directing it at the proper angle into a succeeding rotor; the vanes *M* of the rotors and *N* of the stators are made with reverse curves, as shown in Fig. 4. As the passages for the steam in both directions are the same, a description of its flow in one direction will answer for both.

The steam is not expanded down to exhaust pressure in the nozzles, so the lower surface of the space between the vanes of the central rotor, which first receives its impulsive force, diverge from the center outward, increasing the port in depth

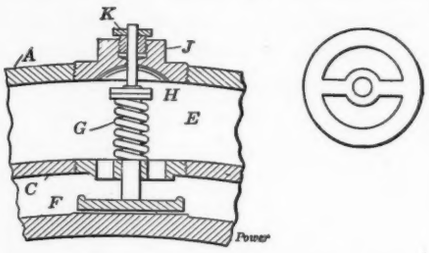
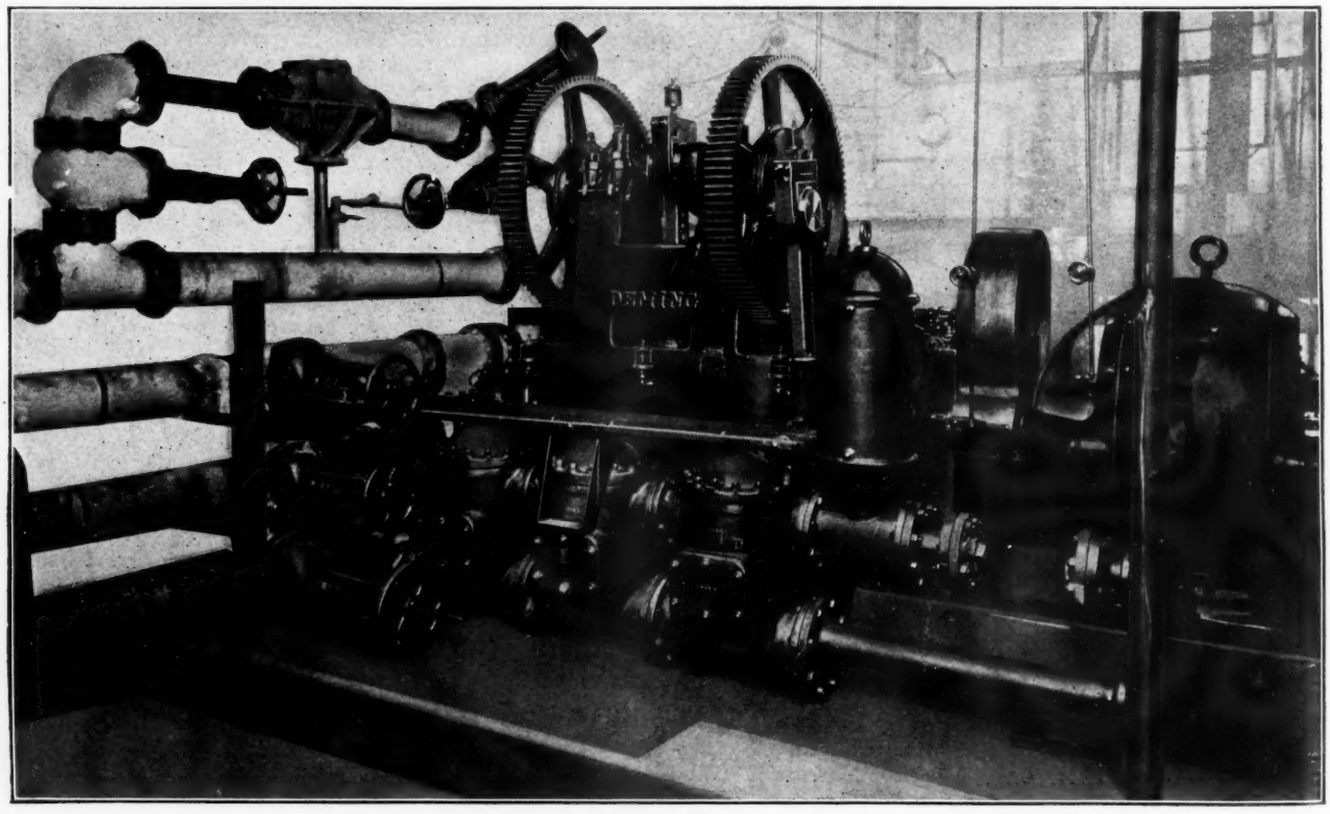


FIG. 5. ENLARGED VIEW OF THE NOZZLE-CONTROLLING VALVE

and area, which proportionately increases the steam expansion and velocity. It then passes to the oppositely curved blades of an abutting stator, entering openings between them of the same enlarged area, and travels one-half the distance through them on the same plane, when the blades increase in depth as described for the rotor vanes, further increasing the steam expansion and velocity, and also directing it in the second rotor at a proper angle. A sufficient number of rotor and stator stages are employed to utilize all the available impulsive and reacting energy in the steam. Each set transforms into velocity an equal portion of the total pressure energy, and passes the balance in the form of pressure along to succeeding sets to the end, when the steam is allowed to escape into an exhaust chamber *O*, Fig. 2, from which it may be piped to any convenient point. The exterior ends of the rotor blades are finished to a running fit with the interior of the casing, and likewise the rotor sides adjacent to the stators. The rotor and stator vanes may be dovetailed in a projecting flange and otherwise secured by bolts as shown, or any suitable method may be employed for securing them.

A Notable Feed Pump Installation

Two triplex motor-driven feed pumps, built by the Deming company, Salem, O., have recently been installed in the plant of the Eastman Kodak Company, Rochester, N. Y. These pumps supply 5000 horsepower of boilers, the pressure on the delivery side of the pumps being 140 pounds per square inch. Each takes its supply from the feed-water heater under a head of from 3 to 6 feet and handles the water at a temperature of 210 degrees. The larger pump, shown in the accompanying illustration, has 9x10-inch cylinders and runs on an average at 25 revolutions per minute. It is fitted with



DEMING MOTOR-DRIVEN TRIPLEX FEED PUMP

a Mason combination pressure-regulating valve connected between the discharge and suction, and the motor is of the variable-speed type. The smaller pump runs at 30 revolutions per minute and has 7x8-inch cylinders. These pumps have all the characteristics of the Deming construction, including bored crosshead guides, machine-cut gearing and bronze boxes with wedge and screw adjustment at the crosshead ends, and marine type babbitted boxes at the crank end. The valve chambers are separate castings bolted to the cylinders, making all valves readily accessible for repairs. This style of outfit, mounted on a cast-iron subbase, makes a desirable combination where economy of space is essential and electric power is available.

Evening Technical Courses at Pratt Institute

The Pratt Institute, at Brooklyn, N. Y., is conducting a series of evening technical courses, adapted to the requirements of men who are engaged during the day. The classes meet on Monday, Wednesday and Friday, from 7:30 to 9:30, and from September 28 to March 24. The courses comprise practical mathematics, technical chemistry, industrial electricity, elementary electricity and practical mechanics, electrical machinery, electrical design, mechanical drawing, machine design, mechanism, steam and steam engines and strength of materials. For the course upon steam and steam engines, examinations in arithmetic only are required. The course is intended primarily for young men who are anxious to fit themselves to become competent stationary engineers, or who are preparing to pass examinations to obtain an engineer's license. It covers the study of steam and the steam engine and steam boilers, fuel and steam generation, properties of steam, condensing and noncondensing engines, advantage of single, compound, triple expansion, etc. Laboratory practice includes valve setting, indicator work and the making of engine tests for power, steam consumption and efficiency, pump tests, gas-engine styles, etc. The tuition fee is only $15 for the season of six months. The Pratt Institute has an excellent equipment both of apparatus and instructors, and by taking a number of these courses successively a man who is obliged to earn his living in the daytime can acquire a knowledge not only of drawing and mathematics, but all the technology which is essential or useful in his vocation.

Brooklyn Trade School

The Brooklyn Evening Technical and Trade School gives a number of free courses to young men of ability who have their evenings at their disposal. A two-year course in industrial chemistry, which may be followed by a third year in quantitative analysis; electrical engineering, preceded by necessary mathematics; steam engineering, qualifying men to set up dynamos and engines, and test and regulate them, also elementary civil engineering, may be taken up by the students.

I. U. S. E. Hold Convention in Denver

During the week of September 12 to 17, the International Union of Steam Engineers held its annual convention at Denver, Colo. Matt Comerford was re-elected as president and J. G. Hannahan, of Chicago, was elected secretary. Further particulars will be published as soon as available.

SOCIETY NOTES

The National Association of Manufacturers, of which John Kirby, Jr., is president, has removed its general offices from 170 Broadway to 30 Church street, one of the twin Hudson Terminal buildings in New York City. The association's growth during the past few years necessitated more commodious quarters than could be obtained at the Broadway address. The editorial and advertising departments of *American Industries*, the association's official magazine, and of *Export American Industries* (English and Spanish editions), have also removed to the new location.

At a meeting of the executive committee of the National Gas and Gasoline Engine Trades Association, held in Racine, Wis., August 31, arrangements were completed for the next convention of the association to be held in that city, December 12 to 15 inclusive. The local committee at Racine has arranged for suitable entertainment and a very cordial invitation is extended to anyone who is interested in any form of internal-combustion engines to attend the convention. Special arrangements will also be made for the entertainment of ladies who accompany members or visitors.

PERSONAL

John B. Milliken, controller of the Crocker-Wheeler Company, of Ampere, N. J., has accepted the position of treasurer of the Yale & Towne Manufacturing Company, of Stamford, Conn. Mr. Milliken's headquarters will be in New York.

Arthur Fritsch was recently appointed by the Pawling & Harnischfeger Company, of Milwaukee, as manager of the Chicago office, Monadnock block, succeeding W. E. Kreamer, resigned. Mr. Fritsch was formerly connected with the engineering and sales department of the Allis-Chalmers Company.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., George Westinghouse; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., W. W. Freeman, Brooklyn, N. Y.; sec., T. C. Martin, 31 West Thirty-ninth St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U .S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next annual meeting at Chicago, Oct. 10-13, 1910.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS.

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; sec. and treas., Prof. F. E. Sanborn, Ohio State University, Columbus, Ohio.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill.

NATIONAL DISTRICT HEATING ASSOCIATION.

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

BUSINESS ITEMS

The Bigelow Company, New Haven, Conn., has just sold to the Pacific Mills, Lawrence, Mass., for use in its worsted department, twenty 175-horsepower Manning boilers. This order makes a total of over 11,500 horsepower of fire-tube boilers sold to this concern by the Bigelow company during this year.

The Pawling & Harnischfeger Company, of Milwaukee, designer and builder of traveling electric cranes and hoists, announces the appointment of Arthur Fritsch as manager of its Chicago office in the Monadnock block, succeeding W E. Kreamer, resigned. Mr. Fritsch was formerly connected with the engineering and sales department of the Allis-Chalmers Company.

The H. W. Johns-Manville Company has found it necessary, owing to the great increase of business in the vicinity of Atlanta, Ga., and Rochester, N. Y., to open offices in those cities. The Atlanta office is located in the Empire building, in charge of W. F. Johns, who has been traveling that territory for the company for a number of years. The Rochester office is located at 725 Chamber of Commerce, in charge of H. P. Domine, formerly with the Buffalo branch of the company.

While the Joseph Dixon Crucible Company, of Jersey City, N. J., is the oldest and largest graphite concern in the world, there are no doubt many more or less recent users of graphite who may not be fully acquainted with its line. The name Dixon has always been associated with flake graphite, and it is flake graphite alone that the Dixon company provides for lubrication. The word "flake" seems to give some the impression that the Dixon graphite is coarse. It is true that a large flake graphite known as Dixon's No. 1 is prepared, but in addition to this there are two finer grades, that known as No. 2 and that indicated by the number 635. This last, while a flake graphite, is ground to an impalpable powder. Under the microscope its flake formation is evident, but to the naked eye the flakes are not appreciable. The No. 2 graphite is about one-half way between the No. 1 and No. 635. These three grades (referring to size of flake) cover every lubricating requirement that occurs in the power house and machinery field, from heavy, slow-moving bearings to the very finest and closest set ones. The Dixon company is always glad to take up the lubricating problem with any who may desire to avail themselves of their experience.

NEW EQUIPMENT

North Bay, Ont., will install new waterworks.

Oakland, Ill., will install a waterworks system.

Harlowton, Mont., will install a waterworks system.

The city of El Centro, Cal., will erect a pumping station.

Strathroy, Ont., will install new waterworks machinery.

Baker Bros., Toledo, Ohio, are erecting a new power house.

The town of Rippey, Iowa, voted to issue waterworks bonds.

Collyer & Keyworth, Gardner, Mass., will install a steam boiler.

Arlington, Tenn., contemplates installation of waterworks system.

New Liskeard, Ont., is in the market for waterworks equipment.

The Geo. E. Belcher Company, Stoughton, Mass., will install a boiler.

The Earle Fruit Company will erect a packing house at Turlock, Cal.

Alice, Texas, contemplates issuing $35,000 waterworks and street bonds.

L. O. Koven & Bros., Jersey City, N. J., will build a new power house.

The St. Croix Gas Company has been granted a franchise at Hudson, Wis.

The Rensselaer (N. Y.) Water Company will enlarge its pumping station.

The Range Power Company, Chisholm, Minn., will install a steam plant.

Swift & Co., Jersey City, N. J., will erect a $150,000 cold-storage warehouse.

The Modern Power Company will locate a large new plant at Winnipeg, Man.

The Montreal (Que.) Hydro Electric Company will locate a plant at Montreal.

The Purity Ice Cream Company, Watertown, S. D., will erect a new plant.

Franklin, N. C., will vote on issuance of $24,000 bonds for waterworks system.

The Center (Tex.) Light and Ice Company will increase the capacity of its plant.

Orillia, Ont., will spend $30,000 for new electrical equipment for power purposes.

The Chapin-Sacks Ice Company, Washington, D. C., will erect additional buildings.

Gomery Brothers, Allentown, Penn., will erect a cold-storage and ice-making plant.

The British Columbia Electric Railway is extending its power plant at Vancouver, B. C.

John I. Beggs, of Milwaukee, Wis., will erect an electric power house at Menosha, Wis.

City of Maysville, Ky., will vote on issuance of $50,000 bonds for an electric-light plant.

Regina, Sask., will buy large quantities of electric machinery for its light and power plant.

The Washington County Hospital, Hagerston, Md., will install boiler, engine and pumps.

The C. C. Garrigas Machine Company, Bristol, Conn., will install boilers, engine and pumps.

The Henderson (N. C.) Power Company will rebuild its electric-light plant, recently burned.

The city of Harlan, Ky., is having plans prepared for the construction of an electric-light plant.

J. B. Thompson, Gilbert, Minn., will be granted a franchise to install an electric-light plant.

The Straight Electric Company, Des Moines, Iowa, is considering the erection of a plant at Dows, Iowa.

H. F. Pierce, Bay City, Mich., has been granted a franchise to erect a lighting plant at Crosby, Minn.

The U. S. Bobbin and Shuttle Company, Manchester, N. H., is in the market for an engine and boiler.

The Farmers Creamery and Produce Company will erect a creamery and boiler room at Newell, Iowa.

The Astoria (L. I.) Heat, Light and Power Company will erect new meter house, pump house and boiler house.

The power house and electric-light plant of the Ruby Gulch Mining Company, at Zortman, Mont., were burned.

The Hospital for Children and Training School for Nurses, San Francisco, Cal., will erect a new boiler room.

Thos. D. Miller, of New Orleans, La., has been granted a franchise to install a gas plant at Cedar Rapids, Iowa.

The Canadian Coal Corporation, Salmon Harbor, N. B., will need a large amount of steam and electrical equipment.

The city of Toledo, Ohio, is preparing to extend the city filtration plant. Additional pumps and engines will be installed.

W. F. Turner and J. W. Barker have been granted a franchise by the town council, Atkins, Ark., for an electric-light plant.

The city of Pittsfield, Mass., is considering the installation of a new pumping station. Electric power pumps will be installed.

The Hydraulic Power and Manufacturing Company, Niagara Falls, N. Y., contemplates making extensive additions to its power plant.

The Western Canada Power Company, New Westminster, B. C., is in the market for large quantities of electrical equipment of all kinds.

Bids will be received until September 29 by the United States engineer, Wheeling, W. Va., for two 115-horsepower boilers, two steam-driven air compressors.

The Navy Department, Bureau of Supplies and Accounts, Washington, D. C., will open bids October 4, for 30 testing generators, 10 electric heaters as per Schedule 2890 and air compressor, Schedule 2905.

NEW CATALOGS

The Babcock & Wilcox Company, 85 Liberty street, New York, Chas. C. Moore, Pacific coast manager, 99 First street, San Francisco, Cal. Catalog. Stirling boiler. Illustrated, 22 pages, 8x10 inches.

Buffalo Steam Pump Company, Buffalo, N. Y. Catalog No. 228. Vacuum pumps, jet, barometric and surface condensers. Illustrated, 62 pages, 6x9 inches.

Saginaw Manufacturing Company, Saginaw, Mich. Catalog. Gilbert wood split pulleys. Illustrated, 40 pages, 6x9 inches, paper.

Wright Manufacturing Company, Detroit, Mich. Catalog No. 12. Steam traps, water columns, exhaust heads, filters, etc. Illustrated, 44 pages, 6x9 inches.

Jeffrey Manufacturing Company, Columbus, Ohio. Bulletin No. 42. Coal-handling and mine equipment. Illustrated, 48 pages, 6x9 inches. Booklet No. 28. Conveying machinery for handling stone, sand, etc. Illustrated, 28 pages, 3½x6 inches.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

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